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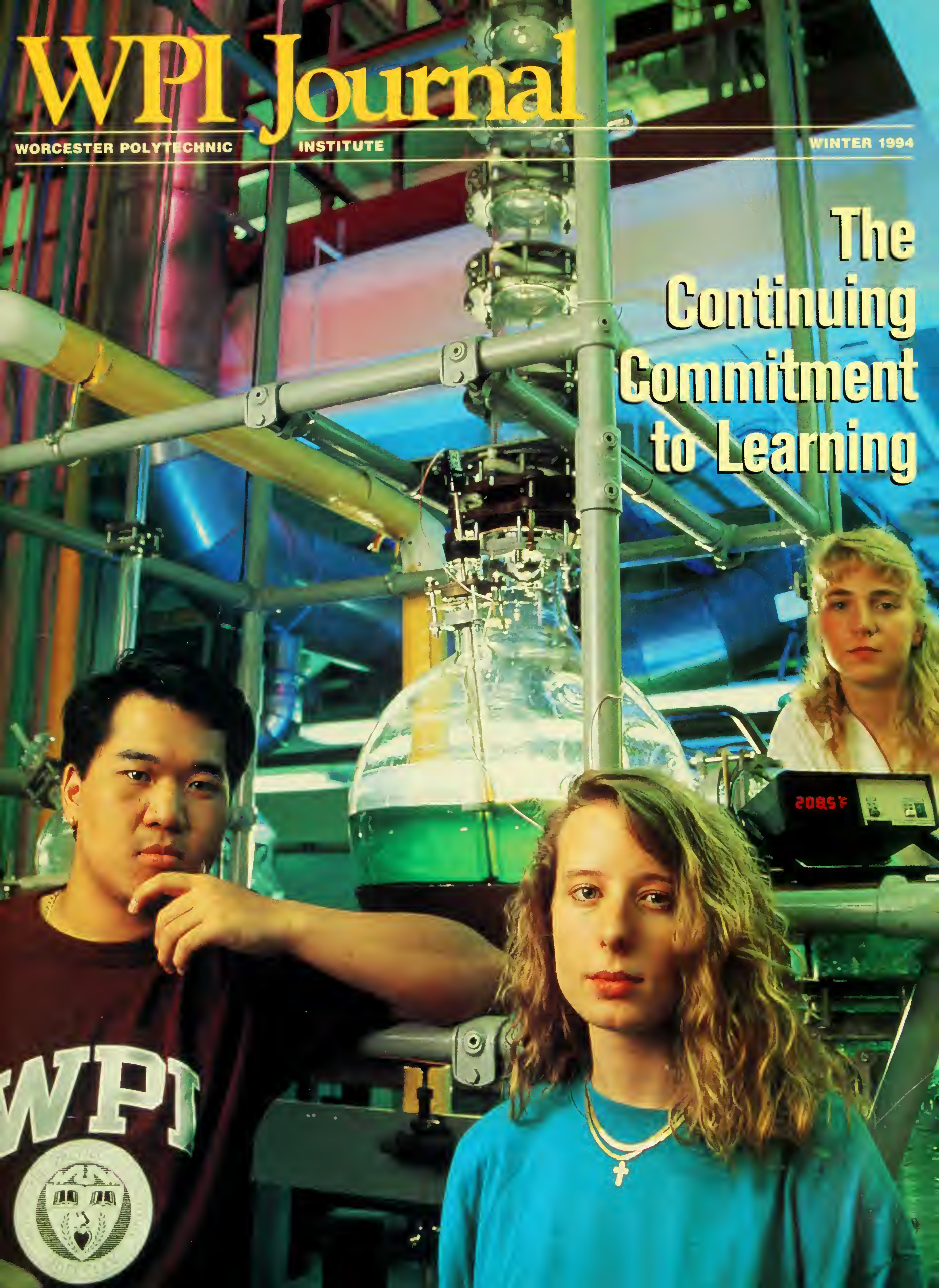
WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

WINTER 1994

The Continuing Commitment to Learning



Front Cover: From left, chemical engineering majors Avery Chan '94, Jennifer D. Wilke '94 and Amy L. Gilman '94 in the Unit Operations Laboratory of Goddard Hall. Finding ways to help students learn better is the focus of a host of initiatives all across campus. Photo by Jim Raycroft. Stories begin on page 6. This page: Students make their way through the aftermath of one of the many storms that have dumped more than seven feet of snow on campus this winter. Photo by Janet Woodcock. Back Cover: Over the years, many songs have vied for the title of WPI's alma mater. Photo by Janet Woodcock. Story on page 30.

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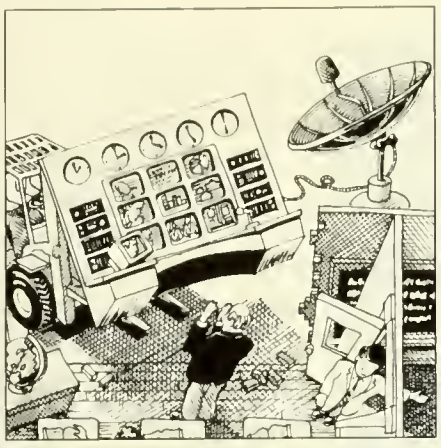
VOLUME XCVII NO. 1 WINTER 1994



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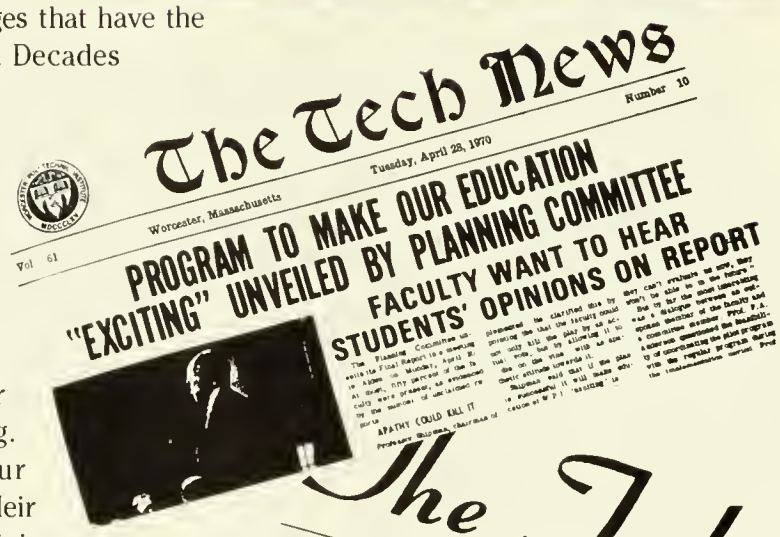
A Year of Remembering When

Every year is filled with events that are tragic enough, joyous enough or surprising enough to linger in the memory long after the year is over. But certain years stand apart from the rest. They crackle with the electricity of human drama and emotion. They seem filled with changes that have the power to define our times. Decades later, just the mention of the year brings back vivid images of people and moments.

Such a year was 1969. Sirhan Sirhan was convicted of the murder of Robert Kennedy and James Earl Ray got 99 years for killing Martin Luther King. Richard Nixon became our 37th president and Golda Meir became the fourth prime minister of Israel.


The Tech News

Worcester, Massachusetts Tuesday, April 28, 1970 Number 10

Vol 61

PROGRAM TO MAKE OUR EDUCATION "EXCITING" UNVEILED BY PLANNING COMMITTEE

FACULTY WANT TO HEAR STUDENTS' OPINIONS ON REPORT

APATHY COULD KILL IT

The Tech News

Worcester Massachusetts Wellesley May 1 1968

Suspected in Two Coeds Hall Fire

Limited P Program

Accepted By W.P.I.

Two young women, Miss Lesley Small and Miss Jayne Rossetti

The possibility of a pass fail program at Worcester Tech has taken a step forward with the recommendation of a limited pro-

In 1969 people walked on the moon for the first time, the supersonic Concord took its inaugural flight, and the FDA banned cyclamates. *The Saturday Evening Post* ceased publication, Hurricane Camille ravaged the East Coast, the New York Mets won the World Series, and Charles Manson and company murdered actress Sharon Tate and four others in Los Angeles.

1969 was a memorable year at WPI, as well. Less than a month before the start of the year, President Storke made a major decision. Like many faculty members and administrators, Storke recognized that WPI did a perfectly fine job teaching students to be engineers and scientists. But perfectly fine no longer seemed good enough.

Storke appointed a committee of faculty members to think seriously about WPI's mission and to see if there might not be a better way to provide a technical education. The committee created the framework for what would become the WPI Plan, the groundbreaking undergraduate curriculum that the full faculty endorsed in the fall of 1970.

The Plan was the product of much debate among faculty members, administrators and students. A few of those students were women. The first two female undergraduates enrolled in the fall of 1968, following a vote of the Board of Trustees in the spring of that year to change a century-old policy of admitting only men. The following fall, 24 more women matriculated, making 1969 the year women truly began making their mark at the Institute.

The *WPI Journal* will observe the 25th anniversary of these two pivotal developments of 1969 in upcoming issues. In the meantime, we'd like to invite alumni to play a role in helping shape this coverage by sharing their memories and thoughts with fellow *Journal* readers.

We'd like to hear from women graduates. Tell us about your experiences as female students at a technical Institute where most of the students—and faculty members—were male. What were some of the challenges you faced? Who, or what, made your WPI years easier? How do you feel your WPI education—and your experiences as a woman at WPI—prepared you for your career? What has your experience been like in your career? Have you faced obstacles or realized rewards your male colleagues have not? Humorous recollections are encouraged, especially those that show how far we've come.

If you graduated under the WPI Plan, we'd like to hear your thoughts about what you gained from your project-oriented education. Do you think the Plan has helped you in your career and personal life? Did it give you an edge over colleagues from other colleges and universities? What do you think about how the Plan has evolved over the years?

Please write down your thoughts and mail them to the editor, *WPI Journal,* 100 Institute Road, Worcester, MA 01609-2280. You may also fax them to (508) 831-5604, send them via the Internet to mwdorsey@wpi.wpi.edu, or e-mail them via CompuServe to 70337,1557. Our coverage of the 25th anniversary of women at WPI will run in the Spring issue, so we need to hear from you right away. The coverage of the Plan is set for the winter of 1995, so those comments should arrive by July 1.

We look forward to hearing from you.

—MICHAEL DORSEY

African Marketplace a Sign of Changing Times

To the Editor:

I am an African-American alumnus of WPI. It's been many years since I received any kind of information or news from WPI—not that it was sorely missed. When I was a student, WPI was severely lacking in outlets where I could express myself as a black man or satiate my cultural thirsts. In fact, the atmosphere on campus was benevolently repressive.

Imagine my surprise upon receiving the Spring 1993 issue of the *WPI Journal* and reading that WPI had held an African Marketplace as a cultural event, and that there is a Black History Month Committee. I could never have imagined these things happening at the Institute.

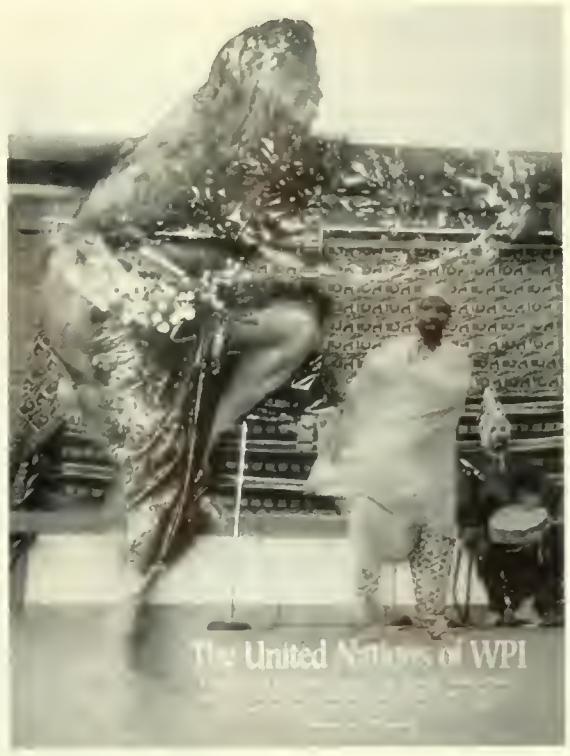
You see, I always felt that the Black Student Union was begrudgingly tolerated by the rest of the school in the 1970s. There was a misanthropic entity named the Tech Conservative Society, full of gloom and John Birch Society, that actively campaigned—on and off campus—against issues like the busing controversy in Boston, financial aid to minority students, and black social activism on campus.

The school's general atmosphere was "New England white" (no offense intended). There were few avenues of cultural satisfaction for black students, most of whom were from urban areas like New York and Chicago.

As a matter of fact, during my four and a half years at WPI (1971-76), the largest number of black students attending the Institute at any one time was 24 (out of a total student body of 1,200). That number also included African students; it doesn't take an engineer to figure the percentages.

All this is by way of saying we felt excluded from many aspects of campus life and student body decisions. There were many times when we felt antagonism and a sense of being unwelcome—especially during intramural basketball games.

This antagonism and indifference was not, however, institutionalized (at least not consciously). Certain members of the faculty and, particularly, the administration tried hard to accommodate the black students, as well as everyone else. I have fond memories of Dean Bernard Brown (now vice president for student affairs) and then financial aid director Ed Heselbarth.



Anyway, wow—an African Marketplace! Are you guys making strides, or what? Thank you for letting me see photos of Lachelle Hatten '95, Naomi Carnegie '93 and Yvonne Harrison. Maybe I can recommend WPI to a young African-American student interested in going to a technical college.

—Benjamin M. Jacobs '76
Brooklyn, N.Y.

Thanks to Pre-health Advisory Committee

To the Editor:

As one of the pre-health professions advisors at WPI, I was particularly pleased to see an entire issue of the *WPI Journal* dedicated to medicine (Summer 1993). As this wonderful issue demonstrated, the impact of technology on the practice of medicine continues to grow, and WPI students and alumni find themselves well prepared to contribute to a variety of medically related fields.

As was mentioned in the introduction to the issue, the number of WPI students expressing an interest in medicine continues to grow, and we rely on the ongoing advice of our Pre-health Professions Advisory Committee to help ensure that our students remain competitive and well prepared for admission to health professions programs.

The committee includes many WPI alumni who are actively involved in medically related careers, and I would like to take this opportunity to publicly thank all of the members for their work. In addition to WPI faculty and staff members, the committee is composed of

— Dr. Nancy Berubé '75, assistant professor of medicine, Family Health and Social Services, University of Massachusetts Medical Center
— Dr. Gail A. D'Amico Mason '79, veterinarian, Bath-Brunswick Veterinary Association, Brunswick, Maine
— Dr. Raymond M. Dunn '78, assistant professor of plastic surgery and clinical director of the Plastic Surgery Research Laboratory, University of Massachusetts Medical Center
— Dr. Richard Glew, physician in chief, Medical Center of Central Massachusetts
— Rebecca A. Griffith '91, medical student, University of Massachusetts Medical Center
— Dr. Karl H. Kraus, assistant professor of small animal surgery, Tufts University School of Veterinary Medicine

— Dr. Peter H. Levine, president and CEO, Medical Center of Central Massachusetts
— Dr. Laima T. Pauliukonis '77, staff anesthesiologist, Sturdy Memorial Hospital, Attleboro, Mass.
— Marilyn Z. Pryor, professor of biological sciences, Mount Holyoke College
— Dr. Thomas M. Villani '82, dentist, Brighton Marine Public Health Center, Brighton, Mass.

As our program grows, we rely on their expertise to keep us on track.

—Jill Rulfs, Assistant Professor
Biology and Biotechnology
and Pre-health Professions Advisor

A Time for Reflection...and Change

By Francis C. Lutz

Leaders of industry, professional societies, and even the Accreditation Board for Engineering and Technology are saying the time is ripe for change in technical higher education. Students in science and engineering programs, they say, need increased awareness of the global society in which technologies are designed, manufactured and used. They need to gain leadership ability, problem-solving skills, and the capacity to communicate orally and in writing. And, everyone agrees, they should acquire eagerness for—or at least comfort with—assuming personal responsibility. Never has there been a clearer call for the original tenets of the WPI Plan.

NEIL NORUM

In meetings with WPI students I have found consistently strong support for the Plan, especially its required projects and its provision for seven-week terms. When students speak about the need for improvement at the Institute, they are most often talking about the social—not academic—aspects of the student experience.

Still, over the past several years, concerns have been raised about our undergraduate curriculum, about the challenges of operating within seven-week terms, and about the meaning of grades and academic credit within the Plan. A self-study of the quality of the learning experience in the freshman year (completed in 1991 as the Institute prepared for its decennial accreditation by the New England Association of Schools and Colleges) affirmed our suspicion that we need to devote more attention to this critical time, when expectations for intellectual responsibility are established.

Last summer, as a result of these concerns, I asked a group of faculty members, administrators and students to prepare some background about the Plan that could serve as a basis for further reflection and reassessment. That group prepared a white paper that critically evaluates the mission and success of undergraduate education at the Institute.

The committee identified a number of issues we need to think about. For example, the seemingly high proportion of above-average grades our students earn seems inconsistent with the low level of effort they themselves say they expend on their studies. This doesn't bode well for our commitment to maintain our standards of academic excellence.

"At an institution so well known for educational innovation, curricular review and change is a process that never stops."

The white paper was distributed to all faculty members in December, and in January I challenged them to use it as the starting point for a much needed campuswide curriculum review. WPI is a recognized leader in moving engineering and science education toward a broader, liberal/professional blend that emphasizes life-long learning. But to maintain that leadership, we must focus anew on the process of learning and on what we can do to improve it.

One thing we can do right away is more clearly define our expectations for students and our standards of academic achievement and conduct. We must also strive to create a campus environment that facilitates learning.

The learning environment is already evolving—even without our help. Just think of the tools our students have at their disposal. They may supplement their studies for many of our courses by reviewing old tests and completed homework assignments borrowed from students who've taken the courses. Through the Internet, they will soon be able to see the lecture notes of faculty members at other universities. And it won't be long before they are routinely using things like virtual reality simulations and self-directed multimedia. Developments like these challenge our traditional ideas about teaching and learning.

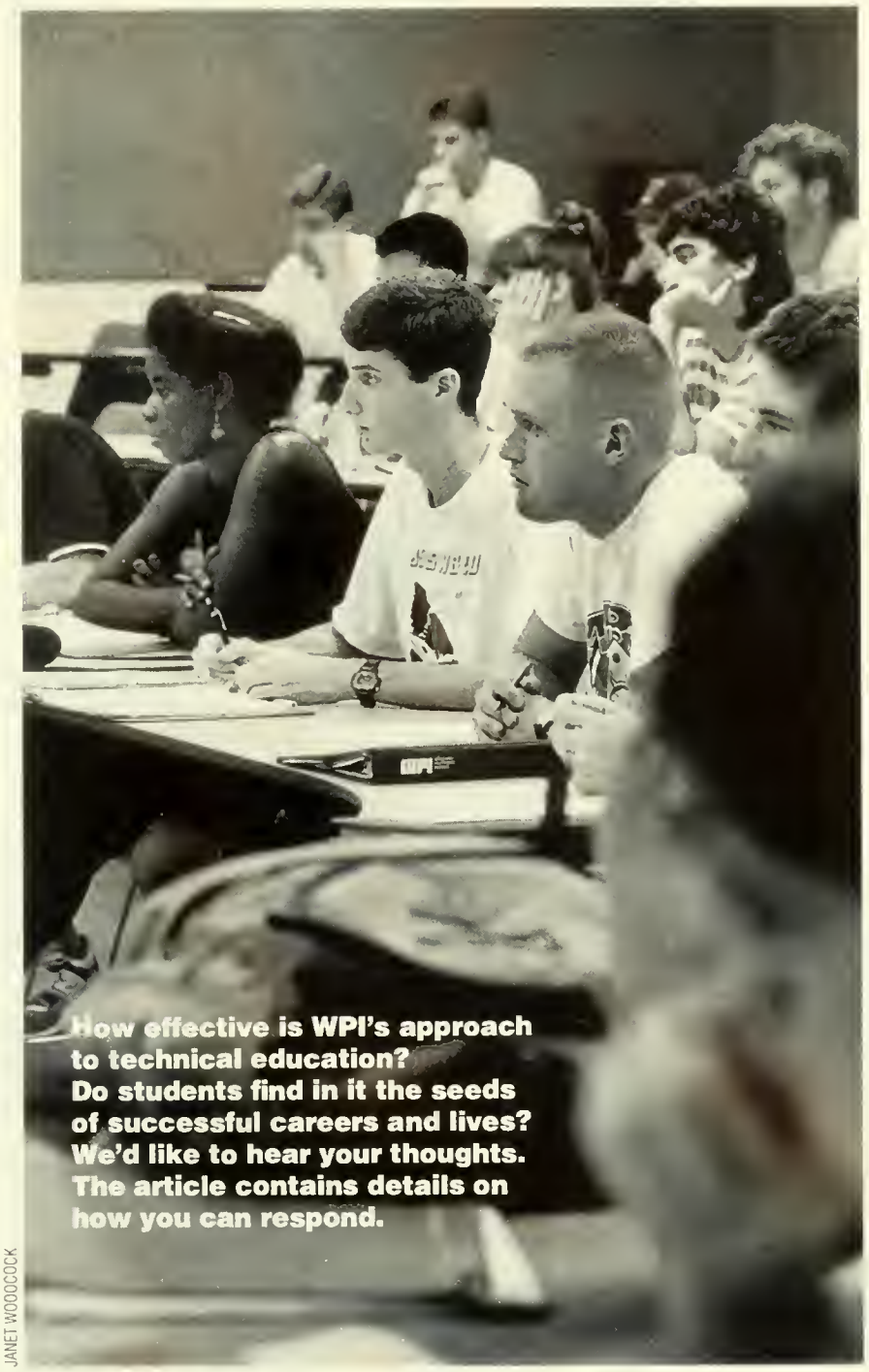
Student learning is closely linked to what has come to be called faculty productivity. As colleges like WPI continue to grapple with tight budgets, they must find ways for faculty members to make more productive use of their time while still maintaining—and possibly enhancing—the quality of learning. One way to accomplish this is for faculty to become managers of the learning process, using students as active partners to help teach other students. We must also acknowledge more fully that students have responsibility for their own learning.

The quality of teaching and learning is also affected by what faculty members do outside of the classroom. In recent decades WPI has emphasized the vital importance of faculty scholarship. In large part this is because faculty members who are actively involved in a community of scholars make more effective instructors. There should be no debate about that.

A related issue is the need to better define the relationship between our undergraduate and graduate programs. It is unlikely that we will achieve any measure of success if we don't set out to merge these two levels of education into one continuous program.

We may even find that better aligning undergraduate and graduate education results in less pressure on faculty and our budget.

These are not unrelated issues that can be addressed in isolation. We need to conduct a forward-looking curriculum review that begins with the aspirations of individual departments and culminates in a common commitment to learning. Such a commitment should encompass not just the Institute, but our partners in the educational process: comparable universities, the professions our students pursue, the graduate schools that educate our alumni, the high schools that prepare our freshmen, the colleges that educate our transfer students, the publishers of our teaching materials, and the practitioners who define the state of the art in the disciplines we teach.



JANET WOODCOCK

You will see as you read this special issue of the *WPI Journal* that the process of reviewing and changing WPI's curriculum is already well under way. (In fact, at an institution so well known for educational innovation, curricular review and change is a process that never stops.) The articles on pages 6-19 describe the many departmental curricula that are being reworked, the revision of our approach to mathematics instruction, the exciting pilot program in cooperative learning being supported by the Davis Educational Foundation, and many more initiatives. These are all part of what is turning out to be an exhilarating era of educational change and revitalization.

At the same time, we are beginning to address some of the larger issues facing us as educators. A group of faculty members, under the leadership of Lance Schachterle, assistant provost and associate dean of undergraduate studies, is evaluating the learning experience in that critical first year. More than 60 faculty members attended an all-day workshop on that topic in January.

Looking to the future, I've asked all of our academic departments to examine the curricula of similar departments at other colleges and universities with which they wish to be compared favorably. We need to see how we measure up in such areas as course content, depth of coverage, level of specialization, curricular flexibility, opportunity for independent work, and exposure to laboratory learning.

Once we have this base level of comparison, I have called on the faculty to establish the process by which our curriculum can be re-examined, not only to assure the competitiveness of our undergraduate program, but to renew and enhance our common commitment to excellence throughout the Institute.

As the leaders of American industry call for exactly the attributes the WPI Plan set out to foster, and as accrediting organizations begin to recognize the value of outcomes over inputs in measuring the success of the educational process, the need to assess and validate what we do here at WPI becomes more critical. As we do so, we must be prepared to accept constructive criticism and be willing to make whatever changes will strengthen our programs.

Making changes is not enough, of course; curriculum innovation should lead to improvements in learning. Therefore, measuring the learning that takes place in our program is a critical endeavor. We need to verify that the changes we make achieve the goals we establish. One particularly powerful outcome is how well the education we deliver serves our graduates as they pursue their careers and lives.

Accordingly, I would be most interested in hearing from you. How has your WPI education affected you? If you are a Plan graduate, did the projects—Sufficiency, IQP and MQP—make a meaningful contribution to your experiences as a professional and as a person? How might we go about improving the education we offer? How can we best document our sincere belief that WPI graduates are competent in their major disciplines? Would you or your organization agree to participate in a comparative analysis of achievement of graduates of WPI and other schools?

Please send me your thoughts. The address is WPI, 100 Institute Road, Worcester, MA, 01609-2280. You can also reach me by fax (508-831-5774) or e-mail (fclutz@jake.wpi.edu). We look forward to hearing from you. You may be assured your observations will have an effect on the curricular review we are beginning.

Lutz is dean of undergraduate studies at WPI.

Reinventing the

By Michael W. Dorsey

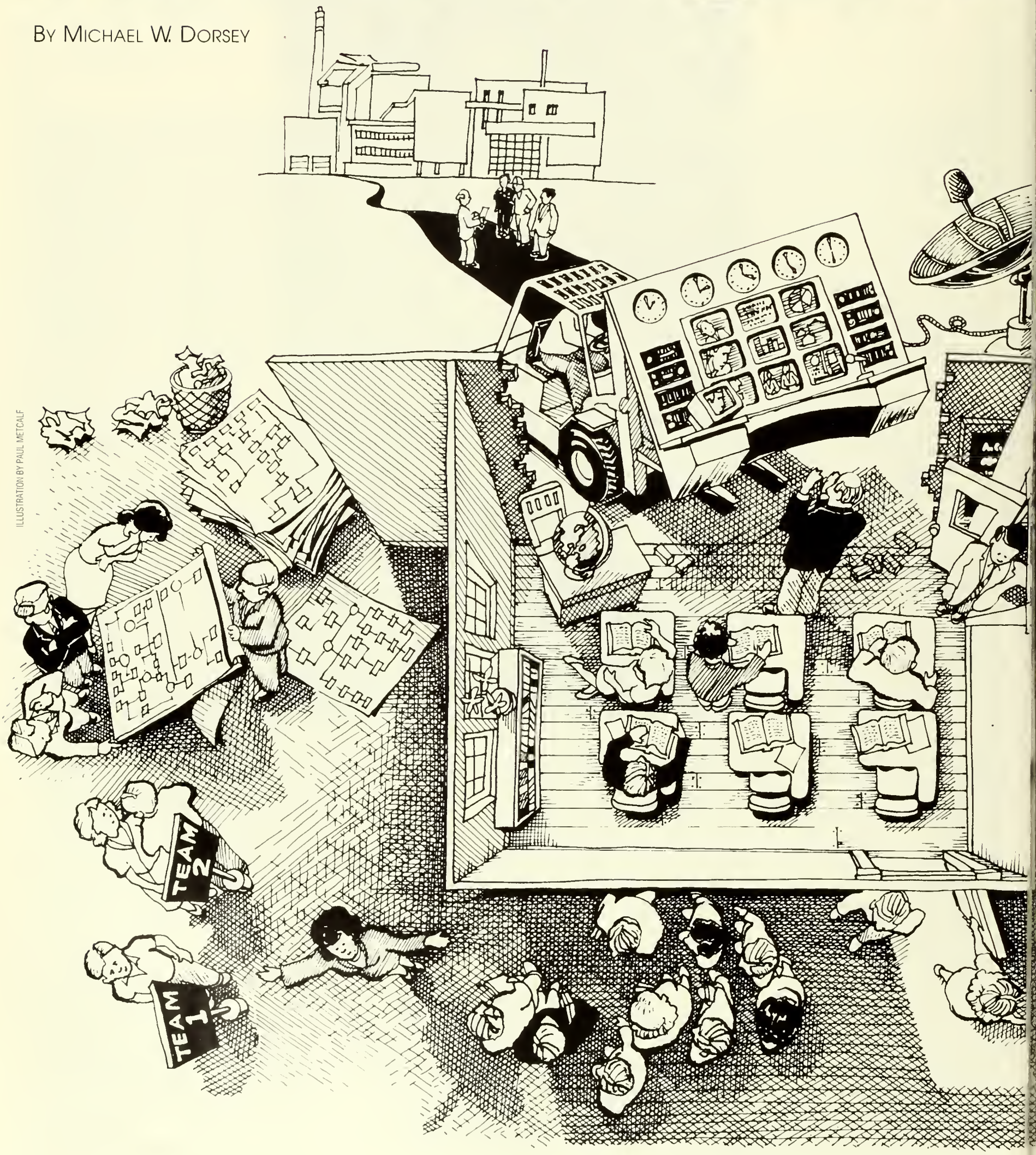


ILLUSTRATION BY PAUL METCALF

Classroom

In every corner of the WPI campus, efforts are under way to rethink, recreate, rebuild and remold the undergraduate curriculum. With restructured courses and sequences, new classroom and lab technology, and new ways of delivering information, WPI continues to lead the way in educational innovation.

Today, many of the nation's leading technological colleges and universities are engaged in a spirited effort to revamp their decades-old approach to teaching students to be engineers and scientists. There are some practical reasons behind this flurry of activity, a recent article in *Business Week* noted.

For one, traditionally rigid engineering and science curricula encourage students to strive for individual achievement—good grades—even though corporate leaders say they need professionals who can work in teams to achieve common goals. While most technical programs have been built around well-defined academic disciplines with tightly drawn borders, the work of engineers and scientists today is increasingly multidisciplinary.

And despite tremendous advances in computers and laboratory equipment, basic math and science courses are taught today much as they were half a century ago, with the result that students never really see how these subjects relate to their future careers and must wait until more advanced courses to experience the excitement of hands-on design and research.

WPI got a head start on the rest of the pack when it created the WPI Plan 25 years ago. The shapers of the Plan understood the shortcomings of classical technical education that many of today's reformers are just now beginning to address. Through the years, the Plan has demonstrated its ability to prepare the kinds of engineers, managers and scientists industry needs—professionals able to work in teams, to lead, to think critically, to solve problems, and to communicate well. As society has evolved, the Institute has continued to assess its undergraduate program, frequently taking time to stop and ask, "Are there better ways to teach—and better ways for students to learn?"

Over the past several years, with the dawn of a new millennium fast approaching, that question has been asked with increasing frequency by individual faculty members and academic departments. More and more, it is being tackled by the Institute as a whole (see Communiqué, page 4). In the pages that follow, we report on a few of the products of this soul-searching.

One of the most promising of these products is a program in cooperative learning funded by the Davis Educational Foundation (see page 13). Another exciting program, the Entrepreneurs Collaborative, is seeking to teach students the skills they need to be entrepreneurs and to bring an entrepreneurial perspective to the companies for which they work. For more on that initiative, see the Winter 1994 *WPI Wire*.

Rethinking the Curriculum

At least five academic departments have recently taken on the substantial task of evaluating and improving their undergraduate curricula. The Chemical Engineering Department, for example, is reorganizing its curriculum around three possible paths—environmental engineering, bioprocess engineering and advanced materials.

"Working within the requirements of ABET [Accreditation Board for Engineering and Technology], we will have a variety of courses—some already developed, some under development, and some offered by other departments—that will enable a student to get a degree in chemical engineering with one of these three interests," says Albert Sacco Jr., head of the department.

The idea, Sacco says, is to make sure students have a solid grounding in chemical engineering while gaining a degree of specialization in an area in which they may like to work. The new sequence will also expose students more fully to the social and policy issues with which professional chemical engineers must grapple. "With this approach, we feel we can graduate better, more marketable chemical engineers while maintaining our ABET accreditation," he notes.

The Civil Engineering Department has been working on its undergraduate and graduate programs for a few years, notes Department Head Robert W. Fitzgerald. "We concluded that we are comfortable with the undergraduate course offerings, in general," he says. "A few of our basic courses had gaps and overlaps, which we've addressed."

One major effort has involved integrating the computer into the curriculum. A new freshman/sophomore-level course on computers in civil engineering has been pilot-tested (see page 17). A second pilot course on computer-aided design software in civil engineering is heavily oversubscribed. Both will be prominent in the curriculum.

The department has also been placing a major emphasis on student advising, addressing the question of whether civil engineering majors should specialize in a single subdiscipline or acquire a broader exposure to the field.

"Students often think it is best to go down a narrow path," says Fitzgerald. "We feel it's best for undergraduates to have a good grounding in the fundamentals, a strong computer background, and some depth in two or even three areas of civil engineering. In addition to better speaking and writing skills and an understanding of professional practice, these are the qualities employers tell us they seek."

Fitzgerald says the civil engineering faculty also wants to help students plan their entire curriculum to make the best use of their projects and courses in mathematics, science, the humanities and other disciplines. "We don't intend to dictate, of course," he says. "All we hope to do is provide guidance on how students can construct an entire program that best meets their goals and needs."

"The question we tried to answer is, 'What will a mechanical engineer need to know by the year 2010?' With that in mind, we looked at the content of every course we teach." — Mohammad Noori

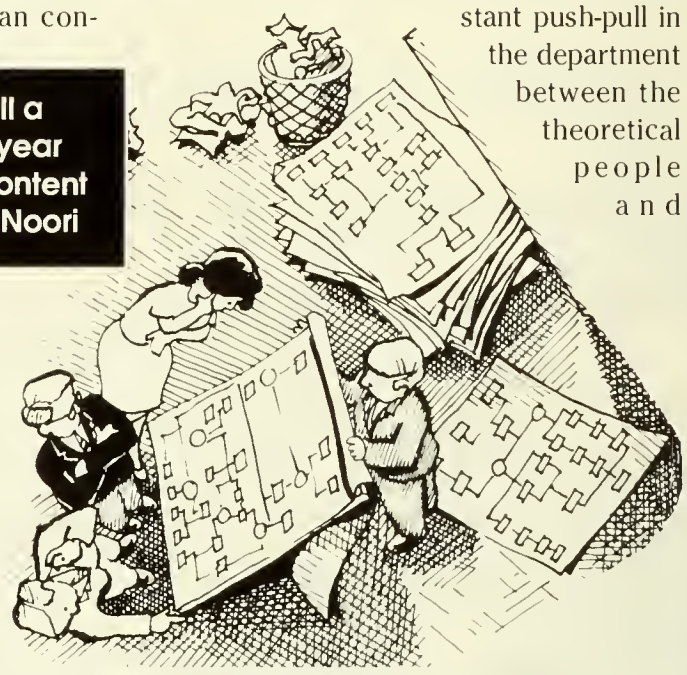
A major effort to rebuild the undergraduate curriculum in the Electrical and Computer Engineering Department began in 1991 with the appointment of the Phoenix Committee, made up of six members of the ECE faculty. "There were several good reasons for this review," notes Department Head John Orr, "but the most important is that the practice of our profession is fundamentally changing."

The explosion of new technology like fiber optics and VLSI chips, the shift from a technology-driven to a customer-driven orientation in industry, and the increasing reliance of engineers on computer software led the committee to conclude that the 20-year-old introductory sequence, which took circuit analysis as its basic starting point, was no longer appropriate.

The committee threw out a two-course sequence that all ECE majors take and created a four-course sequence that also takes the place of the first laboratory course in electrical engineering and a recently introduced survey course. The new sequence, which students may begin in the freshman year (most engineering students take their first engineering course in the sophomore year, Orr says), provides a comprehensive overview of electrical engineering.

"In part," Orr says, "the change was designed to help students understand what electrical engineers actually do. Students report major increases in their level of understanding of the profession, compared with students in the previous sequence. Students also understand better the importance of mathematics and physics in electrical and computer engineering."

While the Phoenix Committee was getting down to work in Atwater Kent Laboratories, next door in Fuller Labs the Computer Science Department was evaluating the introductory sequence for its majors. Like ECE, Computer Science has fashioned new courses for the freshman and sophomore years. But the department remains divided over a basic element of the new sequence: the choice of a primary computer language, notes Department Head Robert E. Kinicki.



"There is a constant push-pull in the department between the theoretical people and the nontheoretical people as to which is the best way to teach students," he says. "The theoretical side wants to stay abstract, but the practical side wants to make sure our students can get jobs."

The new sequence replaces courses developed four years ago that were built around a language called Scheme, a dialect of LISP, which is used extensively in artificial intelligence. Unlike many other computer languages, Scheme is based on formal mathematical logic, and Kinicki says many students seemed to have trouble learning to program using these abstract concepts.

The new sequence exposes students first to C, a language widely used in science and engineering. "Frankly, we were losing some students who were not mathematically strong enough to hack the Scheme approach," Kinicki says. "Plus, I believe that most companies want C programmers."

Students now learn programming and data structures in a two-course introductory sequence based on C. They begin to meet up with the more abstract elements of computer science in three new sophomore-level courses. The sophomore courses also introduce students to object-oriented programming, a technique of rapidly growing importance in industry.

The more theoretically oriented members of the faculty are not entirely happy

with the new arrangement, Kinicki says, and the process of evaluating and fine-tuning the new sequence will continue, as will efforts to revamp the remainder of the undergraduate major program.

"Our department spends a lot of time debating our approach to education, which is very, very healthy," he says. "At schools where they don't care much about the curriculum, they don't take the time to debate. I let the debate go on until I think there is a direction in which we can move forward."

The Mechanical Engineering Department has just finished an intensive effort to restructure its undergraduate curriculum, notes Department Head Mohammad N. Noori. The curriculum, if approved by the faculty, will be implemented in the 1995-96 academic year. (Some new courses may be offered as early as this fall.) The process coincides with plans for a major renovation of the department's home, Higgins Laboratories, scheduled to begin this spring. The renovation will include the creation of a host of new educational facilities.

"For the past 30 years, the traditional mechanical engineering curriculum has changed little," Noori says. "While the content of our courses has certainly evolved, we've been teaching the same types of courses for decades. With all of the changes taking place in the discipline, we decided we had to address this issue."

Divided into four groups representing the primary directions ME is taking—applied mechanics, design and manufacturing, materials science and engineering, and thermal-fluids—the mechanical engineering faculty met weekly to talk about how best to prepare students. "The question we tried to answer is, 'What will a mechanical engineer need to know by the year 2010?'" Noori says. "With that in mind, we looked at the content of every course we teach."

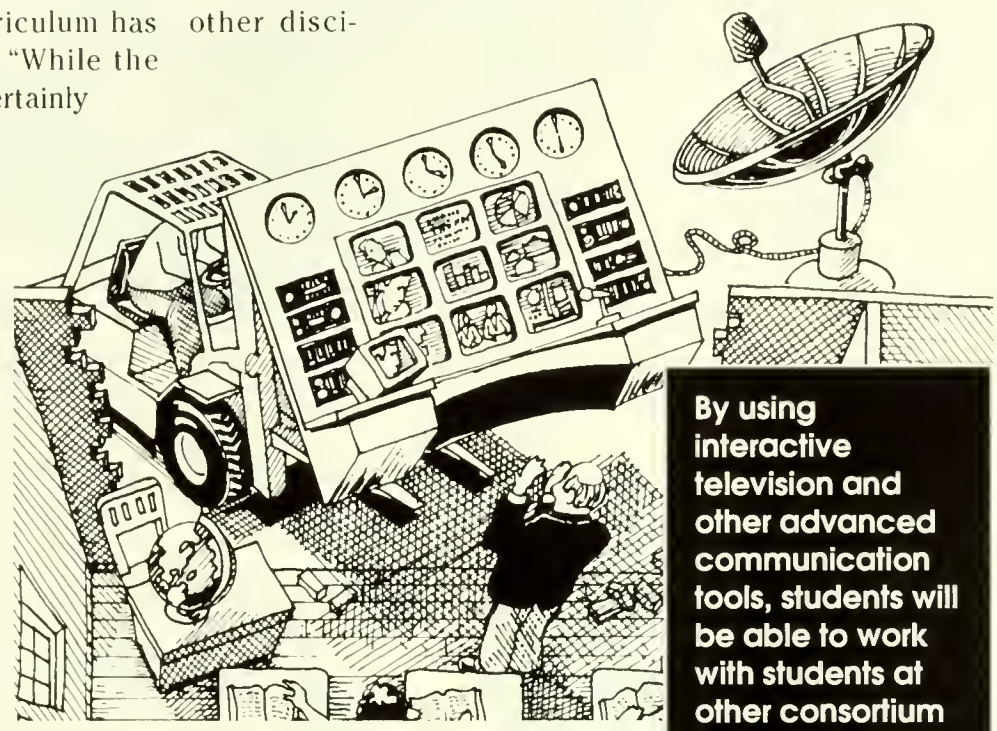
Noori says several major reports published in recent years have concluded that mechanical engineering, which has become a highly compartmentalized field, must foster greater interaction among its subdisciplines if it is to continue to meet the needs of industry.

"Within each of our working groups," he says, "we've succeeded in identifying multidisciplinary areas that can cross these borders. For example, we are exploring the possibility of offering a program that will bridge the gap between materials science, an experimentally based field, and mechanics, an analytical and computational discipline."

Through efforts like this, the department will rebuild its curriculum from the ground up. In all, between seven and eight new courses will be created and changes will be made in another 15 to 20. Some courses will be eliminated. "This has been an enormous effort," Noori says.

A committee is also working on the deveopment of a freshman-year-experience course in which students will be exposed to hands-on projects and an overview of various engineering disciplines—not just mechanical engineering. "After much discussion, we realized that this should not be an ME course, but should be taught to students in all engineering disciplines," Noori says.

"We also decided that whenever a mechanical engineering course has multidisciplinary content and can be of interest to all engineers, it will carry the designation 'engineering science,' rather than mechanical engineering. We've already changed six ME courses to ES courses. Mechanical engineers need to know about other disciplines and vice versa. That's what the real world is all about."



By using interactive television and other advanced communication tools, students will be able to work with students at other consortium colleges and to interact in real-time with professional engineers at corporations.

Building Tomorrow's Classroom Today

At the White House on Oct. 22, 1993, Richard D. Sisson Jr., professor and associate head of the Mechanical Engineering Department, watched proudly as President Clinton announced the winners of the first round of 41 grants under the Technology Reinvestment Program (TRP), a federal program aimed at helping business and industry weather the transition to a post-Cold War economy.

Among the winners was the REALIZATION Consortium, a group of five colleges headed by WPI. With $8.6 million in TRP and industry funding, the consortium, which consists of WPI, Cornell, MIT, North Carolina A&T and Tuskegee, will seek to create nothing less than a whole new way of educating engineers. (WPI is a key member of the Massachusetts Manufacturing Modernization Partnership and the Massachusetts Bioengineering Center, which also received TRP awards. For more, see the Winter and Spring 1994 issues of the *WPI Wire*.)

Sisson says the REALIZATION Consortium grew from the acknowledgement that while engineering education has traditionally been effective in teaching students to analyze and solve problems, it has done a poor job of teaching them how to effectively meet customer needs.

"The focus of the consortium is on that transition from customer need to final product," he says. Because there were no models within engineering education for such a program, Sisson says he and his colleagues looked at how students are prepared for other professions. They found the models they were seeking in architecture and medicine.

"We asked the dean of architecture at MIT how they train architects to be creative, because you need creativity to go from a customer need to designs you can analyze and test. He said, 'We give students a fuzzy problem—a general definition of what we're looking for in a building. We have them work to solve it and we provide criticism while they do it.'"

At the end of the project, the student designs are evaluated by a jury of architects from around the world. "This all happens in real time," Sisson says. "The criticism is right there in front of them. The experts may disagree, but the students learn by listening to the discussion."

The other model, Sisson says, is the teaching hospital. Doctors learn to practice medicine by being given the responsibility to care for real patients. "They learn by

doing," he says, "but all the time there are experienced physicians who offer criticism and suggestions."

From these examples, the consortium developed the Learning Factory, the framework for a new way of educating engineers. In addition to the idea of real-time critiques found in the architecture and medicine models, the Learning Factory stresses teamwork.

"Engineers don't work alone," Sisson says. "Through the consortium, we are going to give students the opportunity to work in geographically dispersed teams, something that is becoming quite common in industry." By using interactive television and other advanced communication tools, students will be able to work with students at the other consortium colleges and to interact in real-time with engineers at corporations.

The focus for all this activity will be the Design Studio of the Future, one of the new facilities in Higgins Labs, where students will work on progressively more complex design problems during their four years at WPI. Like the projects assigned to architectural students, the problems will be open-ended.

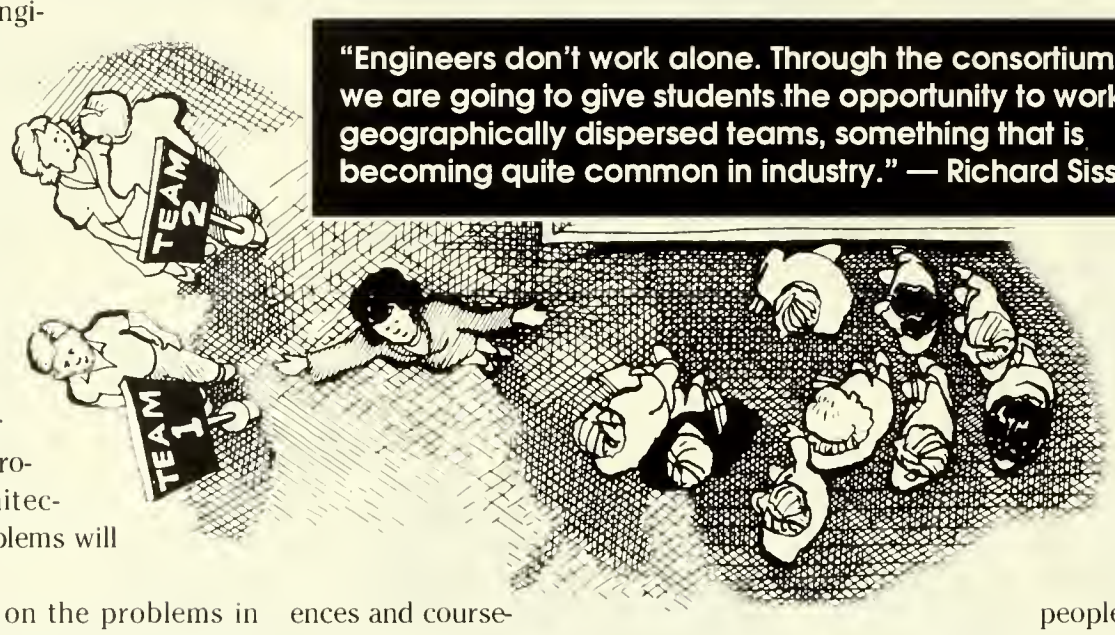
Students will work on the problems in multicollege teams. They will use advanced computer-aided design tools and will also have access to a variety of equipment located on the campuses, at manufacturing companies, and in government labs for making prototypes of their products. "This will be a virtual design studio," Sisson says, "because not all of the colleges will have all of the equipment. But once you have a CAD file, you can send it over a network to another location to be produced."

The ideas for the projects will come from companies affiliated with the consortium. The students will be required to carry their ideas right through to working products. As they work, they will consult with engineers at the sponsoring companies, getting feedback on how well they are meeting the customer's needs and designing a quality product that can be made quickly and cheaply. At the end of the year, projects will be evaluated by a design jury.

Since completing such open-ended assignments will encourage students to seek out information and skills that may not be taught at WPI, Sisson says a key element of the consortium will be the development of modular courseware—multimedia instruction modules that students can consult on a "just-in-time" basis. "The idea of modular courseware fits well with WPI's philosophy of helping students learn how to learn," Sisson says.

As they work on their projects, students will come to understand the importance of such basic concepts as project management, the design process and brainstorming, he adds. "If they do this four times during their careers at WPI, they will learn well how do these things."

A critical goal of the initiative is to create a model that other universities can adopt. Over the next three years, the consortium colleges will work with 15 affiliate institutions to teach them how to run a learning factory. The consortium will also share its experiences and courseware through workshops and other vehicles. And the Society of Manufacturing Engineers will build a duplicate of the Design Studio of the Future at its headquarters in Dearborn, Mich., to serve as a showcase for its member manufacturing companies.



"Engineers don't work alone. Through the consortium, we are going to give students the opportunity to work in geographically dispersed teams, something that is becoming quite common in industry." — Richard Sisson

One important idea the consortium will share, Sisson says, is how to manage student project work. "WPI is the lead institution in this consortium for a number of reasons," he says. "First, we have one of only 10 ABET-accredited programs in manufacturing engineering in the country. But just as important, we have more than 20 years of experience with student projects and we have a lot we can teach other schools."

Reforms Are Adding Up in Mathematics

Like a trip to the dentist, studying calculus has been an unpleasant but necessary chore for generations of engineering and science students. Characterized by tedious lectures and homework problems, calculus has always seemed far removed from the practical, hands-on education students get in their other courses.

But it doesn't have to be that way, says Samuel Rankin, head of the Mathematical Sciences Department. Having been active in the mathematics education community and having served as a reviewer of proposals for calculus reform grants for the National Science Foundation, Rankin became convinced not long after he joined WPI in 1987 that "we had the right faculty to change things, and that WPI was the right setting for change."

Rankin says two basic alterations were needed. First, it was important to introduce computers into the calculus courses to make it possible for students to be exposed to more complex problems than the simple textbook examples they were doing by hand. Second, it was critical that students see how calculus is actually used to solve engineering and science problems.

"Mathematicians have been guilty of teaching everyone as if they were mathematics majors," Rankin says. "We have to remember we are teaching people who want to use mathematics but who don't necessarily want to devote their careers to it."

In 1988 the department began experimenting with a new calculus curriculum that introduced computers into classroom instruction. Then in 1990 it received a two-year, $119,000 grant from the NSF to develop a more comprehensive overhaul of the calculus sequence.

Under the direction of William W. Farr, associate professor of mathematical sciences, a pilot course was run in the fall of 1991. The course introduced two principal innovations: the use by students of a computer algebra system called Maple and the assignment of multiweek projects in which students use calculus to solve problems drawn from engineering and science.

"One of the problems with most calculus courses," Farr says, "is that students tend to focus on manipulations. They never learn *why* they should use calculus, *how* to use calculus, or *when* to use calculus to solve problems. As engineers and scientists, that's what they need to know."

Now, in addition to attending lectures, students spend time in a computer lab working in groups on exercises that teach them

about using calculus—and the computer—to solve problems. The lab itself, with its 23 workstations, was funded by a major grant from the NSF; the department has applied for more NSF funding to add a second lab.

During the course, the students also tackle several complex, open-ended projects. They are given three weeks to complete each one and to write a technical report summarizing how they attacked it. "In the reports I look for a student's ability to mix words and equations, knowing when to use each to describe what they've done mathematically," Farr says. "To do well with these reports, students really have to understand what they are writing about."

It was important to introduce computers into the calculus courses to make it possible for students to be exposed to more complex problems (and) to see how calculus is actually used to solve engineering and science problems.

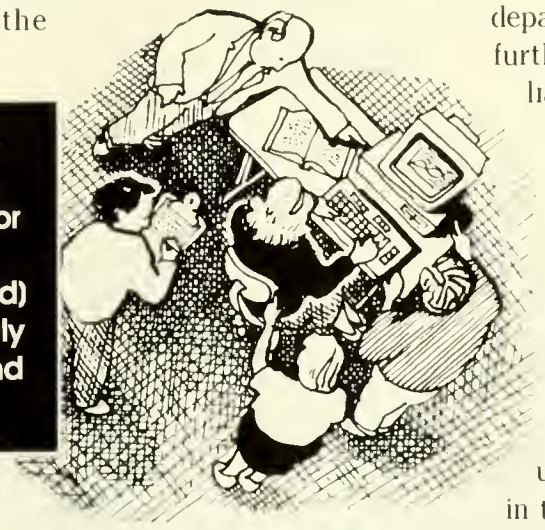
Many of the problems students are assigned—such as designing a crankshaft or studying the economics of an electric power system—are suggested by faculty members in WPI's engineering and science departments. In complexity and relevance, they are far removed from the problems calculus students typically see, Farr says.

While the new calculus sequence was being implemented, another team—Professor Joseph D. Petruccelli and Assistant Professors Balgobin Nandram and Minghui Chen—was revamping the basic statistics sequence with a $165,000 NSF grant. Like the new calculus courses, the statistics sequence relies heavily on the computer and on learning through group projects.

In pilot classes in the fall of 1993, the three instructors took somewhat different approaches to teaching statistics. For example, while Petruccelli tried to eliminate lectures entirely and have students learn the class material in groups, Nandram gave "mini-lectures" and had students get together in groups only to do projects and lab exercises.

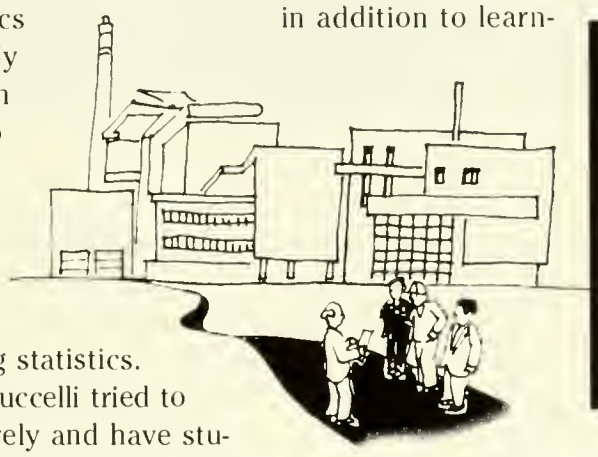
The goal of the new approach, Petruccelli says, is to have students learn how to learn by actually using statistics to solve problems, rather than listening to lectures and reading a textbook. Used to the lecture approach, students were skeptical at first, he says. "Much of the burden was on them and I think they felt that. But in written assessments at the end of the course, some also acknowledged the upside—they had learned a lot."

Farr and Petruccelli say that although they believe the new approaches are promising, formal study is required to prove that the methods really are better for students. Recognizing the importance of assessment in curricular reform, the Mathematical Sciences Department this year hired Assistant Professor Susan L. Ganter, who has made that her specialty.



During the current academic year, Ganter has been working with Farr to assess the success of the calculus program. "At any one time, we have 10 sections of calculus under way," she says. "Four are running under the new model and the remainder under the old model. To compare the two approaches, we gave common finals to students in both tracks."

She says the results show that students in the new sequence, in addition to learning computer skills, technical report writing, and calculus theory and practice, learn the basics of calculus manipulations at least as well as students in the traditional courses. Based on the success of the pilot program, the mathematics faculty will soon be asked to approve switching the calculus sequence entirely over to the new format beginning this fall.



"Since we haven't had the engineering equivalent of Marcus Welby on television, and since students don't study engineering in high school, (the case study) may be their first true exposure to real engineering."
—Christopher Brown

Ganter, who will perform similar assessments with the revised statistics and differential equations courses (see page 18), says she will follow the students who pursued both the revised and traditional sequences to see how they do in later math courses and in their other course and project work at WPI. She also plans to interview students later in their academic careers to assess the impact of the new methods on their attitudes about and ability to use mathematics.

At press time it was learned that the department's reform efforts will expand even further. The National Science Foundation has approved a two-year, $100,000 grant for a revision of the linear algebra sequence. The effort, to begin this spring, will be spearheaded by Assistant Professor Ansuman Bagchi.

"With NSF support, we are essentially realigning and restructuring our entire freshman and sophomore curriculum," notes Rankin, who says his hope is that the department can ultimately transfer what it has learned in these efforts to the entire mathematics curriculum.

Introducing Marcus Welby, P.E.

What does an engineer do? Surprisingly, many engineering students don't really know, says Christopher A. Brown, associate professor of mechanical engineering. To provide a window on real-life engineering for students and to give faculty members a vital link to the concerns and needs of industry, Brown and several colleagues at WPI have turned to the case study, a tool widely used in management education.

Over the past few years, Brown, Richard Sisson, John J. Bausch III, assistant professor of mechanical engineering, Sharon A. Johnson, associate professor of management, James C. O'Shaughnessy, professor of civil engineering, Jeanne Wenzel Ross, assistant professor of management, and David C. Zenger, assistant professor of mechanical engineering, have been developing case studies to use in courses in environmental engineering, materials, management and manufacturing engineering.

The work has been supported by the Society of Manufacturing Engineers, the National Consortium for Business and Technology, and AT&T, which in 1992 awarded WPI a three-year, $200,000 grant to develop the case study approach.

Brown says several case studies have already been developed. In one, which has been used in manufacturing and management courses, students are presented with the problem of determining the real cost of a discrete manufacturing operation like cutting a workpiece with a band saw. A number of factors can affect this cost, including the quality and cost of the blade, the cutting speed, and the cost of operating the machine and changing the blade.

Like the other studies, this one was developed in consultation with corporations, including American Saw and Manufacturing Co. in East Longmeadow, Mass., which, in addition to saw blades, produces software that companies can use to make such calculations. Students use a version of the software as they work on the case study.

"This is a valuable study because we have an industry that is actually doing this kind of thing," Brown says. "We know that some of our engineers will work for companies that aren't aware of how to do this—and that may be wasting money—so we feel we are making a real contribution."

Brown says the greatest value of the case studies is that they expose students to the kinds of things engineers really do. "They use the specialized software engineers use and experience real-life engineering scenarios," he says. "Since we haven't had the engineering equivalent of Marcus Welby on television, and since students don't study engineering in high school, this may their first true exposure to real engineering."

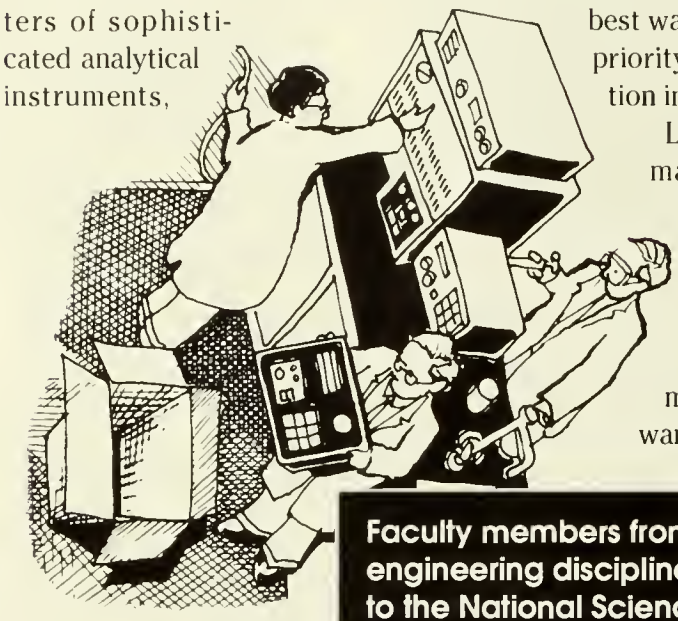
The case studies seem to work. Brown says that after the most recent offering of his materials processing course, where a quarter of the class time is devoted to case studies, 30 percent of students said the studies changed their perceptions about what an engineer does.

But while they are effective, Brown says case studies take far more time than simply preparing lectures. "It takes a graduate student a full term to develop a case study that takes two hours of class time to work through," he says. "You also have to add in a great deal of a faculty member's time. That can seem like an inefficient method of teaching."

To make the idea more feasible for other instructors, Brown and his colleagues plan to write a book about using case studies in engineering education. "We have to sell people on the worth of this method," he says. "But as we look at shrinking budgets and higher student-faculty ratios, there will be less time for such activities. That's why support from organizations like AT&T is so important."

Defining the Future of Lab Instruction

In 1991, the Chemistry Department opened the doors to its new Introductory Chemistry Instrumentation Center. The lab represented a major change in the way students in the Institute's introductory chemistry course would spend their lab periods. Funded, in part, by a major grant from the National Science Foundation, the center houses several clusters of sophisticated analytical instruments, like gas chromatographs, Fourier transform infrared spectrometers and spectrophotometers—the kinds of state-of-the-art tools one usually finds only in a modern chemistry research lab.



Faculty members from virtually every science and engineering discipline have submitted proposals to the National Science Foundation under its Instructional Laboratory Improvement program.

Developed by Professors Nicholas K. Kildahl and Ladislav H. Berka, the center, part of the General Chemistry Laboratory in Goddard Hall, is the focus of a new approach to teaching introductory chemistry that seeks to expose students early in their academic careers to real research. Working in teams, students in introductory chemistry use the instrumentation throughout the course to solve problems and lab exercises.

The idea, notes Department Head James W. Pavlik, is to get students excited about scientific research at a time when they are still considering their career options. "Since most of WPI's 2,600 undergraduates take General Chemistry during their first year at the Institute," he says, "the new center is having a major impact on the education of virtually every WPI student.

"This experience will certainly help prepare our engineering and science students to assume positions of leadership in an increasingly competitive technical world," adds Pavlik, who says the department is working to extend this approach to lab instruction throughout the entire undergraduate chemistry curriculum.

According to Dean of Undergraduate Studies Francis C. Lutz, rethinking the undergraduate laboratory experience will be a major thrust of future curricular reform efforts at WPI. "Because of the real-world work WPI students do through their projects, there is less of a need for hands-on lab work at WPI. On the other hand, to do the projects well, students need to learn hands-on skills, so in a sense there is more of a need for this type of instruction. I've called for this issue—and an examination of the best ways to deliver lab instruction—to be a priority for the faculty and the administration in the months ahead."

Lutz says the appearance of such information-age technologies as computer simulations, teleconferencing and virtual reality may provide opportunities for lab instruction to be delivered in entirely new ways and for universities and academic departments to share equipment and courseware to lower the cost of lab instruction.

A significant move to address laboratory instruction is already afoot on campus, Lutz says. He says faculty members from virtually every science and engineering discipline have submitted proposals to the National Science Foundation under its Instructional Laboratory Improvement program. "We've already received some funds through this program, which supports new visions for lab instruction. It has made a big difference in the quality of education at WPI."

Lutz says is he heartened by the amount of change and reassessment he sees around him today. "There seems to be a recommitment on the part of the faculty to our most important strategic goal: enhancing the excellence of our undergraduate program.

"Our faculty are scholarly people who recognize that there's an awful lot of scholarship in the teaching process. They are active in understanding how teaching and learning interact. And they are deeply concerned about the kinds of skills and knowledge our graduates need to succeed today—everything from the ability to learn how to learn, which enables one to adapt more quickly to changing societal needs, to an understanding of other cultures, so vital in our global economy. It makes for some really exciting times at WPI."

Breaking the Mold

How do you convert students from passive observers to active learners? WPI seeks the answer with a bold experiment in cooperative learning.

By Diane Benison

PHOTOS BY JANET WOODCOCK

Turn and look at the person on your right. Now look at the person on your left. Four years from now, only one of you will still be here."

That sobering prediction was part of the welcome many freshmen received during their first week at WPI—and at many other colleges of engineering and science—as recently as 25 years ago, says Francis C. Lutz, dean of undergraduate studies. It typified the competitive model of education found then throughout much of higher education—particularly in technical disciplines.

The birth of the WPI Plan in the early 1970s created a new model. The Plan reframed student responsibilities and faculty expectations. Students were no longer seen as passive vessels into which the faculty poured facts, the retention of which was measured by tests and rewarded with grades and, ultimately, graduation.

The Plan required each student to complete three projects—the Humanities Sufficiency, the Interactive Qualifying Project (IQP), and the Major Qualifying Project (MQP). These graduation requirements sent a powerful message to students about the importance of integrating and applying what they learned in the classroom to the real world.

Less explicit in the project experience was another message, that of the value of teamwork. Completing the IQP and MQP in teams gives students a preview of life as a professional, since no matter what their disciplines, working engineers, scientists and managers (and, for that matter, social scientists and humanists) must invariably work together with others to design and manufacture products, solve problems, and tackle unanswered questions about the universe.

The cooperative model was a significant step away from the prevailing competitive style of education. But while it has been thoroughly integrated into the Plan's required project work, it has been slower to find its way into the Institute's classrooms. Since most students do not begin work on the IQP and MQP—the projects that are usually completed in teams—until their junior year, their early experiences at WPI often diverge little from the traditional model, Lutz notes.

"During my more than two decades at WPI, I've seen us spend the vast majority of our time on student experiences in the upper classes. It's now time to turn our attention to the freshman experience."

Lutz says he was moved by a statement made by Paul Grey, former president of MIT, who chaired the visiting committee of the New England Association of Schools and Colleges for WPI's 1992 reaccreditation. "He expressed his admiration for the sense of collegiality that the projects create between faculty and students. It's our intention to bring that collegiality into the freshman year."

A major experiment aimed at accomplishing just that began in 1992 with the aid of a two-year, $550,000 grant from the Davis Educational Foundation. The grant is being used to introduce the concepts of cooperative learning into introductory courses.

Last year the grant funded a cooperative learning trial with the introductory biology sequence. This year it is supporting pilot programs in the Civil Engineering, Mathematical Sciences and Computer Science departments. All of this is aimed at finding innovative ways to both improve student learning and increase faculty productivity. To meet these two goals, the pilot programs make teamwork an integral part of the WPI experience right from the start of a student's academic career.

The origins of the program funded by the Davis Foundation can be traced to a project started in 1988 by Ronald D. Cheetham, professor of biology and biotechnology, and Judith Miller, associate professor of biology and biotechnology. The two were assigned the seemingly mundane task of reorganizing the introductory courses designed for biology majors (Biology I and II).

Instead of simply updating the content of the two courses, Miller and Cheetham decided to use the assignment as an opportunity to move away from the traditional lecture and highly structured laboratory format commonly employed in introductory science courses—the "canned lecture/cookbook lab format," as they would later dub it in one of two articles they wrote about their experiences for the magazine *BioScience*.

"Although providing breadth of coverage, the traditional approach allowed for little or no in-depth investigation of single topics," they wrote. "The students memorized buzzwords, but their involvement in the course was minimal. They had no say in the selection of topics or in grading; they had little opportunity or incentive to participate in discussions or to interact with faculty; they had no need to consult primary research literature; and they were usually not required to think analytically or creatively or to organize their thoughts for written or oral presentation. In summary, students in the traditional introductory course participated passively, and consequently there was little long-term retention of course material and little stimulation of student interest."

Cheetham and Miller wanted the new courses to not only solve these problems, but to more effectively "convey the spirit of biology as an investigative science." To do that, they turned to the techniques of active and cooperative learning.

James E. Groccia, director of WPI's Center for Curricular Innovation and Educational Development, says "active learning requires students to solve problems, ask questions, express opinions and support those opinions with reasons—in short, to think actively about the subject being discussed."

Cooperative learning takes that a step further, Groccia says, by having students work in groups. They remain responsible for their own learning, but they are also encouraged to help others in their group learn. The idea is that by cooperating and taking advantage of the synergy of several minds working together, everyone will learn more.

"In its simplest form, cooperative learning is a group of people working together to understand and solve a problem," Groccia says. "It occurs sponta-

neously in families, in social and political organizations, and in the workplace."

In the classroom, cooperative learning can take many forms. Generally, students work together to complete a common task suitable for group work. It can be a highly effective way for students to master material and develop higher-order thinking and collaborative skills, while still holding them individually accountable for their own learning, Groccia says.

Cooperative learning is not a new idea. Increasingly, it is being practiced in elementary and secondary schools across the country, though its use at colleges and universities is a relatively new phenomenon. While it is employed in many ways, cooperative learning has some basic requirements:

—The groups must have positive interdependence that drives all members to want to learn.

—Group members have to help each other learn by sharing, providing constructive feedback, and directly supporting and encouraging positive problem-solving activities.

—Group members must hold each other accountable for doing their fair share of the work.

—Group members must be aware of and able to use appropriate interpersonal skills to communicate and solve problems within the group.

—Groups must be able to discuss the process of learning and group dynamics to assess how effectively group members are functioning together.

Miller and Cheetham taught the revised Biology I and II for the first time in 1989. The new courses had no lectures or traditional lab experiments. Instead, students learned about molecular, cell, organismal and environmental biology by working as teams to solve problems—for example, designing a unicellular organism to colonize the fictitious planet Xenon or a closed life-support system for long-term space flight.

Since the new courses had no tests, grades were based on presentations and reports completed by groups at the end of each project, as well as a self-grading format and some grading of students by their peers. "Students could not passively participate in these courses," Miller says.

Because there were no textbooks appropriate for this approach to biology, Miller and Cheetham wrote their own curriculum materials. (They did ask students to buy a standard text for use as a reference.) The original materials included a core of project modules that asked questions that seemed simple, but which could only be answered after students had acquired a broad knowledge about biology. And unlike the problems typically included in introductory-level textbooks, these questions had more than one possible solution.

To acquire the knowledge they needed, students were encouraged to gather relevant information by reading research material Miller and Cheetham reserved at the library. Students had to evaluate the meaning of the research and its relevance to their tasks, and then work together to synthesize and integrate it into coherent solutions to the problems at hand. Large- and small-group in-class discussions helped students digest what they were discovering.

Student reaction to the trial run was mixed. Many students were unnerved by the lack of structure and by the open-ended nature of the problems. Biology majors worried that they were not learning enough facts to allow them to take advanced courses.

Miller and Cheetham were also finding that active and cooperative learning required more of them as teachers. They discovered that they were putting in almost twice as many hours per week into teaching than they had when they taught the courses in the traditional way. And with far more student-teacher interaction than in a lecture course, they began to see how different cognitive styles affect student learning—especially in groups. Managing the dynamics within the project teams became a time-intensive task.

To address student anxieties, Miller and Cheetham made some changes to the courses in 1990. They added some brief lectures and helped the teams break the problems into manageable components. They added quizzes to assure students that they were, indeed, learning facts, and adjusted the peer-evaluation part of the grading system to increase the incentive for all students to participate substantially in group projects.

To find out how well their new approach worked, Miller and Cheetham secured a small grant from WPI's Educational Development Council. With the grant they commissioned Leonard Goodwin, now professor emeritus of social science and policy studies, to compare the attitudes and academic performance of students in the 1989 and 1990 sequence with those of students who had taken the sequence in 1987 and 1988 under the traditional lecture format.

He found that while many students would have preferred traditional lectures, most enjoyed working in project groups and had come to prefer problems that had more than one solution. Another survey conducted a year after students completed the revised course sequence showed that those who went on to take advanced biology courses said their experience with cooperative and active learning had fired their interest in biology.

Goodwin's assessment also showed that biology majors who took the revised introductory courses did as well in advanced courses as students who had taken the traditional introductory sequence. In fact, instructors of the advanced courses believed they had gained an important edge over other students.

"They were less likely than the previous year's group to expect the TAs or myself to tell them exactly what to do," one instructor said. "The students relied on themselves and each other much more than on the instructor. I got few complaints about the difficulty of the homework."

"This year's sophomore class [which participated in the revised courses] is less afraid to ask questions," another said. "They seem more aggressive, and less likely to remain silent if dissatisfied. They also seem to have provided more highly creative answers on their essay exams...more alternative explanations than any preceding class I have taught."

Dissatisfied with traditional teaching methods, Judith Miller helped integrate cooperative learning into an introductory biology sequence.

James Groccia says cooperative learning improves student comprehension—and faculty productivity—by encouraging students to help each other learn.

Justin H. Marshall '96 presents some of his team's work on one of the weekly projects completed by students in Fundamentals of Civil Engineering.

Cheetham and Miller say they also noticed that students in the new courses developed collegial relationships with each other, creating a camaraderie missing in students from the traditional lecture classes. As they continued to teach the new Biology I and II, they worked with John M. Wilkes, associate professor of social science and policy studies, to study how students' cognitive styles impacted student satisfaction, group formation and group performance.

By the end of 1992, though, as the number of students electing to major in biology and biotechnology was increasing, Cheetham—concerned that the gains in student learning might not outweigh the significantly greater time investment by the instructor—decided to return to the traditional format. Miller, though she also worried about the demands of the approach, wanted to continue using the cooperative learning format. But she knew she couldn't do it alone.

Fortuitously, at around this time, the New England-based Davis Educational Foundation invited WPI to submit a proposal. Worried about the rising costs of a college education, the foundation was interested in exploring ways to increase faculty productivity while still maintaining—and quite possibly improving—the quality of education. The foundation, impressed with WPI's innovative approach to undergraduate technical education, chose the Institute to design a novel approach to the problem that might serve as a model for other colleges and universities.

As Miller and Cheetham were considering the future of their experiment in introductory biology, Lutz, Lance Schachterle, associate dean of undergraduate studies, and Denise R. Rodino, director of foundation relations, were meeting with individual faculty members and faculty groups, trying to find a way to meet the Davis Foundation's challenge. Their aim was to incorporate the project experience developed so successfully in the WPI Plan into introductory courses without unduly burdening instructors with the intensive faculty-student contact characteristic of projects.

Dalin Tang lectures to students in Differential Equations. In addition to attending lectures, students in the course met regularly in small groups.

They decided that one solution might be to have paid student assistants share the teaching load. The idea would be for these assistants, whom they dubbed Peer Learning Assistants or PLAs, to lead small groups of students in solving problems and tackling joint projects.

These group experiences would not only help students understand and learn the course material better, but reinforce the idea that they share a major responsibility for their own learning. And just as important, by managing the learning process, rather than being the primary deliverer of material, a faculty member could handle more students in the same amount of time.

Unlike traditional tutors, PLAs would be carefully trained to anticipate and manage the kinds of issues and interpersonal problems that arise when students work in groups. Without actually showing the groups how to solve the problems they've been assigned, PLAs would help the students stay on track and get their work done.

Seeing a promising model in the experience of Miller and Cheetham, Lutz, Schachterle and Rodino formed a team that included Miller, Groccia and Herbert Beall, professor of chemistry (who had been working on innovative ways to teach introductory chemistry courses), to combine that model with the idea of the Peer Learning Assistants. It was this concept that the Davis Foundation agreed to support with its $550,000 grant.

The idea of increasing faculty productivity, widely discussed in academic circles in recent years, often sparks controversy, Miller says. "Some people view it as making the faculty work harder, or getting rid of some of them and making the rest work harder. But the idea behind the Davis grant is that, because institutional resources are limited, faculty time has to be spent in managing the learning process rather than doing all the nitty-gritty of it.

"Higher education is getting more and more expensive. Colleges are in financial trouble, so it is essential that faculty members use their time as productively as possible. If they can design a curriculum that incorporates appropriate learning tasks and can then train a lower-paid staff to help implement it, their time is better spent than if they were to invest 40 hours a week working one-on-one with students."

Miller is quick to point out that cooperative learning does not mean simply replacing the faculty member in the classroom with a teaching assistant, something for which many large universities have been criticized. "It takes a faculty member who's really serious about and good at teaching to design a cooperative learning course," she says. "The task design is critical and the selection and training of the support staff are critical. It's not as if the faculty member is backing away from teaching. He or she should be the 'guide on the side, rather than the sage on the stage,' as cooperative learning proponents put it."

The Davis Foundation grant, received in the summer of 1992, provided funds for pilot programs aimed at extending the cooperative learning model to other lower-level courses around campus. But the first step was to test the PLA concept using the introductory biology sequence as the model.

Miller and Groccia carefully selected students to serve as PLAs for the courses. They picked students who had already taken the introductory sequence under the cooperative learning format and done well. The PLAs, who were to be paid for a maximum of 10 hours of work per week, were given an intensive three-day training session to prepare them for their role. (One of those PLAs, Juliet K. Vescio '93, wrote a manual that is being used to help train new PLAs. Vescio is now in a Ph.D. program in biology at the University of Virginia.)

The PLAs were expected to work with project teams and to meet once a week with Miller, Groccia and Miller's teaching assistant. At those weekly meetings, the group discussed the students' progress, talked over the problems the groups were experiencing, and, when necessary, brainstormed to find ways to deal with the problems. "They had done this small-

group work before," Miller says, "so they had learned—often by the seat of their pants—how to get along in a group, how to organize the group process, what tends to happen in group dynamics, and how to deal with it."

To help students understand the value of the active and cooperative learning techniques they'd be using in the course, Miller started the first class period with a simple exercise. She told each student to work with one or two neighbors and make a list of what they thought an employer or a graduate school might look for in a new graduate.

"They came up with a list of skills that has little to do with course content and a lot to do with personal skills—thinking, problem-solving, creativity, ability to work well with others, and the ability to present their ideas orally and in writing," she says. "These are remarkably similar to the skills employers are, in fact, seeking. I pointed out how a traditional course, where you memorize stuff out of the textbook and spit it back on the test, is not going to teach you any of these things."

The pilot program in introductory biology showed that the PLA model works, Miller says. PLAs provided the help the small groups needed and reduced the time she had been spending on that task. While she says it still took more time to teach under a cooperative learning format, the difference was only about 90 minutes a week, instead of the 12 to 13 hours when she taught the course without PLAs.

Proposals were solicited from every academic department and reviewed by Beall, Groccia and Miller. Three initiatives were funded for the 1993-94 academic year. A second round of funding will soon be made available for three or four more pilot programs to be run in 1994-95. Here is a look at those first three pilot programs:

Fundamentals of Civil Engineering

This new course, taught for the first time in the fall of 1993, was designed as a cooperative venture for the civil engineering faculty as well as the students. Nine faculty members taught sections, and others helped develop the curriculum, textbook and course materials. Frederick L. Hart, associate professor of civil engineering, was the principal investigator for the pilot project, while Professor Frank D. DeFalco, Associate Professors Robert A. D'Andrea, Tahar El-Korchi, P. Jayachandran and Guillermo Salazar, Assistant Professors Leonard D. Albano and Paul P. Mathisen, Visiting Assistant Professor Cornelia Demers, and Adjunct Associate Professor Norman Wittels made contributions.

According to Hart, the course was intended to achieve three primary goals: to teach students to use computers to solve engineering problems, to make professional presentations, and to generate professional engineering reports; to introduce students to the fundamentals of civil engineering and to introduce them to the field's various subdisciplines; and to teach students to solve engineering problems within a group environment.

Enrollment in the first offering of the course was 12; that jumped to 24—the maximum number of students the department's computer lab can support—for the second offering during the first spring term of 1994. The pilot course will be offered one more time this year. "Beginning next year," Hart says, "all civil engineering students will be encouraged to take this course as the first step in their major."

After a week spent learning the various software packages they will need for their projects, students go on to study a different subdiscipline of civil engineering each week. These modules, which cover structural engineering, environmental engineering, geotechnical or soil engineering, foundations, surveying, construction project management, and engineering economics, are taught by faculty members who specialize in these subdisciplines.

Each module includes a problem that students must solve by working in groups. To complete these weekly assignments, students have to spend time in the computer lab analyzing data and preparing reports and presentation materials. The groups share their results in weekly oral presentations and written reports.

The lectures also have a group learning component, as the instructors are encouraged to use what cooperative learning advocates call the "bookend

approach." After presenting information, the instructor gives the class a small problem to illustrate the application of that information. The students attack the problem in groups, and when they are done the instructor resumes the lecture.

The bookend approach has several benefits, Hart says. Its function is analogous to a mental seventh-inning stretch. The students focus their attention and concentration actively on the material, since they are not passively sitting and listening to a long lecture.

"The idea," he notes, "is to use a short, thought-provoking problem to help students synthesize and reinforce what is being passed on to them."

In addition to the three primary goals, Hart says the faculty hoped the course and the weekly projects would help students understand how civil engineers approach real problems in the field and come to realize how much organization engineers require to tackle problems. "When they first started, I don't think they appreciated that," Hart says. "They didn't understand how much preparation is needed for a group to solve a problem.

"In their weekly projects, we had them take on the roles of the members of a typical engineering team—field project manager, chief engineer, engineer and client. They then had to assign appropriate tasks to each group member and organize themselves to work effectively as a group. They learned that they needed to develop a strategic approach to the problem before they even went into the lab, or they wouldn't be able to make good use of their time.

"We were extremely happy with the way the course worked," Hart adds. "When we had the oral presentations on Fridays, even faculty members who weren't teaching that week would attend. By the end of the course, as many as six or seven instructors were coming to see the presentations because the caliber of the student work was so high. They wanted to see what their colleagues were talking about."

The caliber of the weekly project presentations was not the only indicator of the course's success, Hart says. The cooperative learning model allows faculty to expose students to more content than would be possible in a conventional lecture course. "I think it would be nearly impossible to ask students to cover this amount of material—or material this complex—as individuals," he says.

He says another important benefit is that the course whets students' appetite to learn and better understand the engineering material. "And," he says, "even if students don't like civil engineering, they still benefit by having a chance—at an early stage—to make an informed choice about their career."

Differential Equations

This Davis Foundation pilot project represents one more phase in a 10-year evolution of the way differential equations is taught at WPI. With their grant, Dalin Tang, associate professor of mathematical sciences and the project's principal investigator, and Paul W. Davis, professor of mathematical sciences, decided to use cooperative learning to enhance the changes that have already taken place.

"Ten years ago differential equations was a kind of toolbox course," Davis says. "It gave students a variety of tools for solving specific mathematical problems. But the tools and the underlying physical problems were usually disconnected. The evolution over the past decade has been to teach the content through mathematical modeling—to let the needs for the mathematics evolve from a physical situation."

By modeling real problems—for example, trying to determine why an automobile suspension system oscillates too much on bumpy roads—students come to better understand how to derive differential equations and to appreciate how they are used. Since many of these problems are complex and open-ended, they are too complicated to give to a single student for a homework problem, and therefore lend themselves well to group projects.

With the help of one teaching assistant and eight PLAs, Tang, who taught the course to 175 students in the second fall term, and Davis, who taught 150 students in the first fall term, restructured the course. Under the new format, the class met as a group three times a week in an auditorium for lectures and then gathered twice a week in small groups with the PLAs to review course material and homework and to work on three major projects employing mathematical modeling.

Tang says the group projects were designed to give students practice at working together and at using the group format to improve their learning. Because of the importance of the activities planned for the small groups, Tang says he placed a great deal of emphasis on the PLAs' training.

"I visited the classes of all the PLAs while they were teaching," he says. "I exchanged ideas with them on an individual basis. We had e-mail discussions about teaching format and style, what a typical conference format should look like, and so on. I also asked them to submit their class notes for a certain day and made comments on them."

While most students rated the new format a success, Tang says he and Davis learned ways they can improve the cooperative learning elements to make the course run more smoothly in the future. For example, he says they must spend more time at the start of the course acclimating students to group learning.

In addition, the PLAs need more guidance from the faculty and teaching assistant in managing student groups. And, he says, the instructors should try to build more group activities into the lectures. "I feel there are a lot of things we can do to improve our model before we can claim complete victory."

Tang and Davis say the format also requires some adjustment on the part of the faculty members. Since the small-group sections were handled by the PLAs, the instructors encountered students only in the lecture hall and during regular office hours. And because students had many of their questions answered in the group sessions, they didn't see students as often in their offices. "That's a disappointment," Davis says, "but the good news is that I was able to get other things done, and that's really what we were after."

Techniques of Programming

Like Davis and Tang, Craig E. Wills, assistant professor of computer science, says he found the group component of cooperative learning to be an ideal way to give students in this sophomore-level course for computer science majors first-hand experience, not only with how the real world works, but with complex problems that are more readily solved by a team.

"I think the students learned the concepts of the course by working with each other," he says. "As a by-product, they learned what it takes to build a large software project—how to make it work and how to deal with the problems that can occur."

Wills, who was assisted by two teaching assistants and seven PLAs, divided the 115 students in the class into 28 groups. He lectured to the entire class four times a week, sometimes giving traditional lectures and sometimes incorporating cooperative learning techniques to get students working actively together.

The groups met once a week with the PLAs in a computer lab. Over the course of the seven-week term, the groups, with the help of the PLAs, each completed three programming projects. While the students worked on the projects in the lab, they spent even more time on their own—often with the PLAs—in between lab periods tackling the assignments. They also routinely used electronic mail to communicate with each other and with the PLAs about their work.

Wills says that by having students work together on their projects, he was able to assign them far more complex and realistic assignments than he would have, had the class worked on projects individually. For example, in one project, students wrote a program to manage an airline reservation system, a major undertaking.

Even more, he says, by creating software as a team, students had to come to grips with the need to carefully plan out a group assignment to make sure everyone understands his or her part and to be sure that the finished parts will work together to make a working program.

Successfully completing such a project teaches students as much about human nature and group dynamics as it does about programing, he notes. "Using cooperative learning gave me a really good idea of what group work does for students," he says. "It makes them much more aware of others."

Progress reports on the four pilot projects (including the introductory biology course) were part of a two-day conference on cooperative learning held at WPI in the fall of 1993. The meeting, funded as part of the Davis Foundation grant, attracted faculty members and administrators from WPI and more than 30 colleges and universities around the region. They came to learn how to adapt cooperative learning to college courses and to see how WPI's experiment was progressing.

One of the points speakers at the conference agreed on was that cooperative learning can help reduce the sense of isolation students—particularly freshmen and sophomores—can feel in large lecture courses. As a result, students are more likely to seek help with course content they find difficult and are, therefore, less likely to fall behind. That simple preventative measure can increase student retention—not only within majors, but also within the college, Miller says. "And improved retention rates add another measurable increase in teaching productivity," she notes.

In the next year of the Davis Foundation grant, Miller says the major focus will be on evaluating what was learned from the first round of pilot projects in order to fine-tune the program. Aiding the principal investigators in that task will be formal assessments of the pilot courses conducted by Groccia and the instructors themselves.

Miller says that in many ways, the program has already proved the value of the cooperative learning model and demonstrated some of its most important tenets. "Perhaps most important," she says, "cooperative learning debunks the notion that only teachers teach and only students learn. It puts the process of learning in a new perspective for everyone. Undergraduates come away from the experience more committed to taking responsibility for their learning early in their college careers."

Benison, a freelance writer and former newspaper editor, has written extensively for the WPI Journal. *Her most recent story examined WPI's Global Perspective Program.*

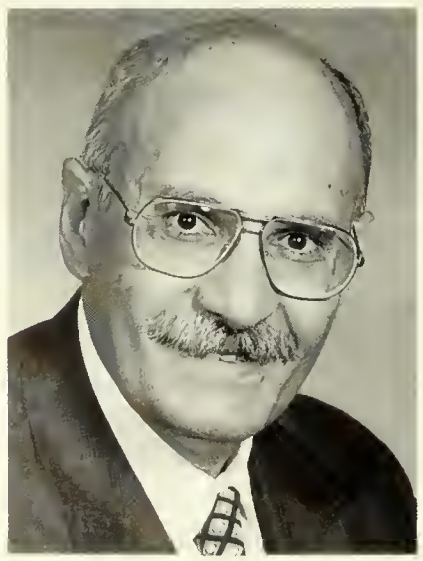
From left, in a small-group session in Differential Equations, PLA Michael Ferraris '95 works with Seann Ives '96, Benjamin Bennett '96 and Shaun Vickers '96.

Craig Wills, far left, confers with members of the teaching team for Techniques of Programming. From left, PLAs Joseph Branciforte '94 and Carla Caputo '96 and TA Paul Maguire.

The Power to Change

By Diran Apelian

A world of issues and opportunities is facing engineering educators. How they respond will not only affect the competitiveness of our nation, but the hope and aspirations of generations of students. In a major address, WPI's provost maps out an agenda for the future.



Engineering education is at a challenging crossroads. Some see it as a crisis; others as an opportunity to position our community and our society for the 21st century. It would be fair to say, however, that no one is satisfied with the status quo or with the prospects for the near term.

The world is undergoing unprecedented change that is affecting not only governments and national boundaries, but institutions of higher education, as well. Colleges and universities that specialize in engineering education, in particular, face many threats.

First, our product is too costly—our customers simply can't afford it. The quantity of financial aid awarded by private universities is staggering, and it escalates year after year. Second, the promise of security and a good job has become less certain. Third, the resources once available to carry out much of the educational enterprise have shrunk dramatically. Fourth, interest among our young people in a technological, liberal education is wavering.

To understand these issues, it is necessary to first examine the historical and social contexts of engineering education.

Historical Context

History shows that our roots and our values can be traced to many different lands. In the U.S., we are heirs to the French and British cultures, in particular. The French were the first to view engineering as an elite profession. In fact, the French word *ingenieur* stems from *genie,* meaning genius. This is quite different from some of the connotations Americans tend to associate with engineering.

Louis XV established a civilian engineering corps, the Corps des Ponts et Chaussees, to oversee the design and construction of bridges and roads. In 1747 the corps created a school to train its members—Ecole des Ponts et Chaussees, the world's first civil engineering school. This led to the founding in France of other technical schools—the Grand Ecoles.

The French recognized early on that engineering is a noble profession that prepares future statesmen and leaders. The mathematician Laplace wrote that the Ecole Polytechnique's goal was to produce young people "destined to form the elite of the nation and to occupy high posts in the state." Over the years the graduates of the Grand Ecoles have proven their "power" by occupying posts in the highest economic strata of French society.

The evolution of engineering in Britain took a quite different path. The English upper class believed in a more classical education. There was no meaningful governmental funding of higher technical education during the Industrial Revolution. In fact, it was not until the early 1900s that both Cambridge and Oxford universities established chairs of engineering sciences. Some argue that Britain's decline as a world power is attributable to its failure to appreciate the importance of engineering education.

In large measure, the Industrial Revolution in Britain was driven by ingenuity and entrepreneurial initiative. Knowledge was gained pragmatically in workshops and on construction sites. Young men became engineers through apprenticeships. As Sam Florman has characterized it, "In France engineering became associated with professional pride and public esteem, with leadership at the highest level. Whereas in Britain, engineering was considered a navvy occupation—the original navvies being the laborers on canal construction jobs."

Both of these cultures permeate the roots of American engineering education. During its early days, the United States had virtually no engineers. When construction of the Erie Canal began in 1817, there were fewer than 30 engineers in the entire nation. We had no

choice but to adopt the British apprenticeship model. The canals and shops, and subsequently the railroads and manufacturing factories, became the institutions where surveyors and mechanics developed into engineers. During the same period, the heritage of the French polytechnicien was also unfolding in America.

West Point was founded in 1802 as a school for engineer officers. Sylvanus Thayer, appointed its superintendent in 1817, visited the Ecole Polytechnique and emulated much of what he learned there. Similarly, in the 1840s B. Franklin Green visited Ecole Polytechnique and assimilated what he learned into the philosophy of Rensselaer Polytechnic Institute. Norwich University, founded in Norwich,Vt., in 1819 on the principles of the citizen soldier, was a hybrid of the military and the polytechnicien. Founder Alden Partridge believed in the importance of a leader of society also serving the nation.

Interestingly, when Thayer, upon his retirement, endowed an engineering school at Dartmouth College, he conceived of a two-year graduate program through which students would become professional engineers only after completing a four-year preprofessional college course. Thayer believed engineers should be "gentlemen" before embarking on a professional education. He wanted the Thayer School to prepare engineers for the most responsible positions and the most difficult service, much in accord with Laplace's concept of the Ecole Polytechnique.

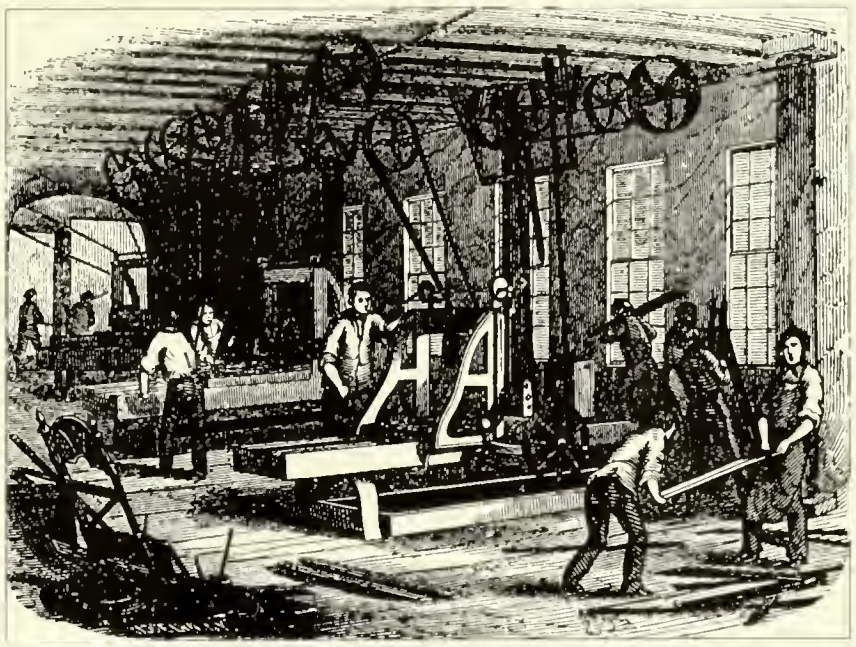
In the 1860s, MIT and WPI were founded. It is interesting to note that WPI's motto, Lehr and Kunst, "theory and practice," bridges the principles of these two cultures. In that same decade, America launched a new era of higher education with the passage of the Morrill Act, better known as the Land Grants Act. This law authorized the federal government to aid the states in establishing colleges of agriculture and the so-called mechanic arts, thereby providing an education for the industrial classes. In the process, engineering became linked with the mechanical arts and American engineers lost the elitism of the French polytechniciens.

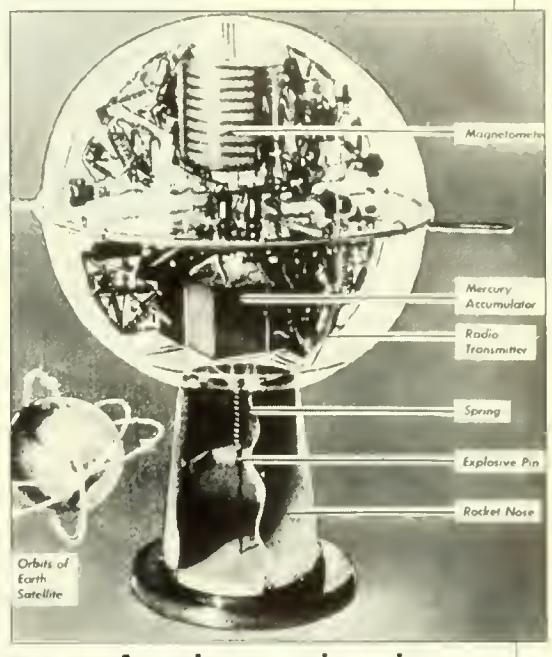
Slowly, the values of the profession were eroded. In time, engineering education was set apart from—and to some degree, below—education for other professions, such as law, medicine and science. The enormous growth of American industry—during and after the Industrial Revolution—and the appetite of industry for engineering employees led to engineers being placed in many subprofessional jobs, further reducing the social status of the profession in America.

During World War II we saw much growth in the technology base of our nation. After the war the masses were educated via the GI Bill. In the postwar period, Vannevar Bush and others were instrumental in establishing the National Science Foundation, which funded the enormous growth in the infrastructure of our research universities. The establishment of the Department of Defense and the growth of the military-industrial complex further fueled this growth, producing engineering graduates who specialized in fairly narrow fields.

The Grinter Report of 1955 was a significant document in that it provided a framework for American engineering education and influenced its revitalization. Its authors assumed that while it would be difficult for colleges to incorporate all of the report's recommendations into a four-year course of study, somehow it could all be packed in. The recommendations did not leave much room for the liberal side of education.

In 1957 the launch of Sputnik and the establishment of NASA spurred an avalanche of interest in science, technology and engineering. In more recent years, we have seen the end of the Cold War and significant shifts in the nation's demographics. These changes present formidable challenges and lead us to question whether the educational process that has served society in the past is still relevant today. Will it serve us well as we enter the third millennium?





The British apprenticeship system (left) was an early influence on American engineering education. In 1957, Sputnik (right) helped fuel an explosion of interest in engineering.

Social Context

From a global perspective, it is crucial that America remain a major competitor. To achieve this, we will need a world-class educational infrastructure. In the early days of this nation, Noah Webster claimed that democracy will succeed only if the people have economic hope and educational hope. They are closely interlinked.

The Competitiveness Policy Council recently forwarded to the White House these goals for the nation:

- Raise national productivity growth to an annual average of 2 percent from the 0.7 percent rate of 1973-91
- Achieve annual economic growth of at least 3 to 3.5 percent and create more high-wage jobs to restore full employment and a higher standard of living
- Eliminate our external balance of trade deficit and halt the buildup of foreign debt that has turned us into the world's largest debtor nation

The council included the following recommendations to the federal government for meeting these goals:

- Through various tax credits and their "competitive life" depreciation allowance, raise private investment permanently by at least 5 percent of GNP
- Develop a major new export expansion strategy to increase export credits, eliminate export controls, and maintain competitive exchange rates
- Improve the education and training of the work force through sweeping reforms throughout the educational infrastructure

K-12 Education

The K-12 education system, the pipeline to our institutions of higher learning, has some shortcomings. First, consider the school calen-

ROBERT S ARNOLD

"More and more, we are coming to realize that females and minorities are not being tracked into science- and math-oriented curricula. As a society, we will be committing suicide if we do not invest in the technical education of all the members of our society."

MICHAEL DORSEY

"Test scores and other evaluations point out that our youth fare quite poorly in [technical literacy] (as well as in basic reading, writing and comprehension skills) when compared with their counterparts in Europe and the Pacific Rim. This is not acceptable; our system must respond."

Top photo, Nancy Teasdale '88 completed an IQP examining solar-powered water pumping systems in Somalia. Bottom photo, high school students compete in WPI's annual Invitational Mathematics Meet.

dar. The three-month summer break was established to enable boys and girls to work on the family farm. In fact, the school calendar was designed to be in sync with the agricultural calendar.

Second, the average American high school senior has about one-third fewer school hours under his or her belt at graduation than his or her counterparts around the world. It's not a great surprise that U.S. test scores are one-third lower; if you work one-third less, you learn one-third less.

Finally, there is a critically important disparity in what students within our nation's schools learn. More and more, we are coming to realize that females and minorities are not being tracked into science- and math-oriented curricula. As a society, we will be committing suicide if we do not invest in the technical education of all the members of our society.

Technical Literacy

The technical literacy of the populace is another serious issue. Test scores and other evaluations point out that our youth fare quite poorly in this area (as well as in basic reading, writing and comprehension skills) when compared with their counterparts in Europe and the Pacific Rim. This is not acceptable; our system must respond.

Demographics

As we look at the demographics, it is clear that we in engineering education have our work cut out for us. The numbers are quite embarrassing and represent a major loss of human potential in our society. For example,

- women, who make up 51 percent of the population and 45 percent of the work force, made up only 7 percent of the engineering graduates between 1950 and 1989.
- Asians, who represent only 2 percent of the population, held 8.6 percent of all bachelor's degrees in engineering and 7 percent of all Ph.D.s in science and engineering.
- at 8 percent, Hispanics represent a growing sector of the population, though only 3 percent of graduates with bachelor's degrees in engineering in 1989 were Hispanic.
- African-Americans, who make up 12 percent of the population, made up just 3.4 percent of the bachelor's degree holders in engineering in 1988.

Our educational institutions must provide a nurturing environment for all students, irrespective of color, gender or race.

Image and Professionalism

The image of engineering must change to reflect the concepts of Thayer and Laplace. I'd like to share with you a story told to me by the CEO of a major French transnational corporation. This CEO was based in the U.S and was returning from France with his senior American staff. As they were going through U.S. customs, he was stunned to see that while he, with a great deal of pride, listed himself as an engineer on the customs form, his staff members, many of whom were engineers of high distinction with Ph.D.s from some of our most famous research universities, had written in "executive" or "manager."

Engineering is the only profession that does not require universal statutory and mandatory licensing as a measure of minimal qualification to practice. Medicine, law, pharmacy, architecture, public school teaching—they all require licensing in addition to an accredited education. Either we must present a clearly defined, unified image to the public, or we should require of all engineering practitioners legally defined mandatory qualifications.

It would be interesting to draw a parallel between engineering education and the concept of the teaching hospital. At a teaching hospital, practitioners teach and the next generation learns from

those who actually practice medicine. However, at most of our universities, the majority of the engineering professors have not actually practiced engineering.

Perhaps we should consider adopting the German model, wherein distinguished engineers from the industrial sector have a duty to teach a course at a university as part of their normal activity, and academicians have close ties to the industrial sector.

Globalization

In constant dollar terms, the U.S. accounted for half of the $2 trillion Gross Domestic Product of the world economy in 1970. Twenty years later, our share of the world's total GDP, now $15.7 trillion, had dropped to one-third, a reflection of the ferocity of global competition.

Industrial globalization should perhaps be measured in terms of the percentage of revenues derived from outside the "home country." Ronald Zarrella '71, president and COO of Bausch and Lomb, has addressed this issue (see "Globalization: The Next Big Wave," Spring 1993 *WPI Journal*).

"For America's 100 largest industrial companies," Zarrella wrote, "the percentage of non-U.S. revenues grew from 14 percent in 1970 to almost 40 percent in 1990. For Japan's largest companies, the percentage is 57 percent; for Germany's, it is 69 percent. Furthermore, for U.S. companies, those revenues have shifted from largely being derived from exports to being derived from manufactured products from outside the country."

NEIL NORUM

Joseph Bucciaglia '91 did his IQP on science education at Worcester's Elm Park School.

There is no doubt that we have a responsibility to ensure that our future engineers can function in transnational companies and can work in a global economy. Because corporations manufacture and sell globally, future engineers must be able to function in such settings.

Imperatives for Undergraduate Education

The societal and historical contexts I've outlined lead to an inescapable conclusion: we must change. Our greatest obstacle is fear of change. As George Bernard Shaw said, "Progress is impossible without change; and those who cannot change their minds cannot change anything...."

In 1962 Gordon Brown, then dean of engineering at MIT, wrote a seminal piece titled "New Horizons in Engineering Education." Questioning the lack of integration in engineering education, he wrote, "Can our present educational structure meet the test of the times? If we assert that we want our students to become men of breadth and vision, able to integrate knowledge, we would ask ourselves whether we are giving them the opportunity to see knowledge in its totality. I believe we are not...."

Integration and synthesis in engineering education is a topical issue. There are several initiatives at various universities and engineering colleges addressing this challenge. At Drexel University, for example, the National Science Foundation in 1989 funded the Enhanced Engineering Education Experience (E^4). The experimental curriculum is integrated around engineering principles and provides students a fresh perspective. The experiment was a success, and Drexel recently adopted this new approach throughout its College of Engineering.

The motivation for the creation of the WPI Plan, the Institute's innovative, two-decade-old undergraduate program, was the acknowledgement of the deficiencies of the so-called passive learning that occurs in conventional classrooms. The weaknesses of the conventional program are many. For example,

- by their nature, conventional courses usually present knowledge in long, isolated corridors, but professional achievement requires extensive integration and application of knowledge.
- a rigid academic program offers few opportunities for students to assume responsibility for defining their personal objectives, but students' success after graduation depends on this ability.
- classroom experience is usually passive, but career development requires self-activation.
- formal classes usually treat students as isolated learners, but practice involves personal interactions, shared experiences, mutual understanding and effective communications.

The philosophy of the WPI Plan was best captured by one of the Plan's founders, Dean Emeritus William R. Grogan '46. He said, "Engineering education must take much more seriously those components that deal with the human dimension: communication skills, management abilities, and significant exposure to social and cultural fields of endeavor."

Nurturing the development of professional values requires immersing students in real-world issues, as the required Plan projects do so well. At WPI, students spend a full year during their last three years engaged in project-based learning.

Project work not only requires a mastery of the technical disciplines, but a command of scheduling, teamwork and communication skills. In addition, the project experience at WPI helps students build self-confidence and promotes the synthesis of fundamental concepts.

In 1988, an NSF workshop on undergraduate engineering education noted that the primary goals of the engineering educational process are to develop, in as individualized a way as possible, certain capabilities in each student. They are

- integrative capability, or the ability to recognize that engineering is an integrative process in which analysis and synthesis are supported by sensitivity to societal need and environmental fragility.
- analysis capability, the critical thinking skills that underlie problem definition—these derive from in-depth understanding of the physical, life and mathematical sciences, the humanities, and the social sciences.
- innovation and synthesis capability, the ability to create and implement useful systems and products, including their design and manufacture.
- contextual understanding capability, the appreciation of the economic, industrial, political and international environment in which engineering is practiced, and the ability to provide societal leadership effectively.

These are critical issues that the faculties of many institutions are addressing. The WPI Plan is an example of a "re-engineered" program that works, though it is labor-intensive and requires tremendous faculty involvement. The underlying theme of the Plan is that, from the student's perspective, there must be meaning and purpose. As T.S. Eliot wrote, "The definition of Hell is a place where nothing connects with nothing." By connecting different kinds of knowledge, the Plan provides a meaningful educational experience.

JANET WOOOCOCK

"We need to take proactive steps to continuously broadcast the value of a liberal technical education in preparing men and women to accept leadership positions in a society that is becoming more and more technological."

JANET WOOOCOCK

"As a nation–and as a profession–we must recognize the extraordinary opportunities that exist in global alliances. We must teach our students to appreciate the beauty of diverse cultures, just as the brilliance of a tapestry comes from the blending of many colors of thread."

Top photo, Kenneth James '90, left, and Ira Nydick '90 did an IQP evaluating the AIDS drug approval process. Bottom photo, students perform a ceremonial dragon dance at WPI's 1993 Cultural Festival.

Conclusions and Implications

Where do we go from here? As a community of scholars, we should consider these recommendations:

National Purpose

Americans have always been individualists, but we have also had a strong, common purpose at our core. We have relied on a common will and a shared culture. We need to rejuvenate and strengthen our national purpose and ensure that our national agenda reflects our values.

Ability to Respond

Apathy and negativism can become self-fulfilling prophecies. We need to respond to the challenges we face in engineering education in an organized manner and with excitement and vigor.

Change of Culture

As educators, we are privileged to be members of a noble profession. We are charged with opening the minds of our students, and challenging and stretching their imaginations. We must not be afraid to open our own minds, as well, and we certainly should not be afraid of the changes we need to undergo. For the fact is, those changes will require courage and a sense of purpose.

We need to change the role of the faculty and the reward system to value the integration, synthesis and application of knowledge, as well as the discovery of new knowledge. Alliances need to be established with the industrial sector, though they will not occur overnight.

Change in Image

We need to take proactive steps to continuously broadcast the value of a liberal technical education in preparing men and women to accept leadership positions in a society that is becoming more and more technological. And we must be sure that the education we offer the next generation emphasizes the importance of studying the impact of technology on society.

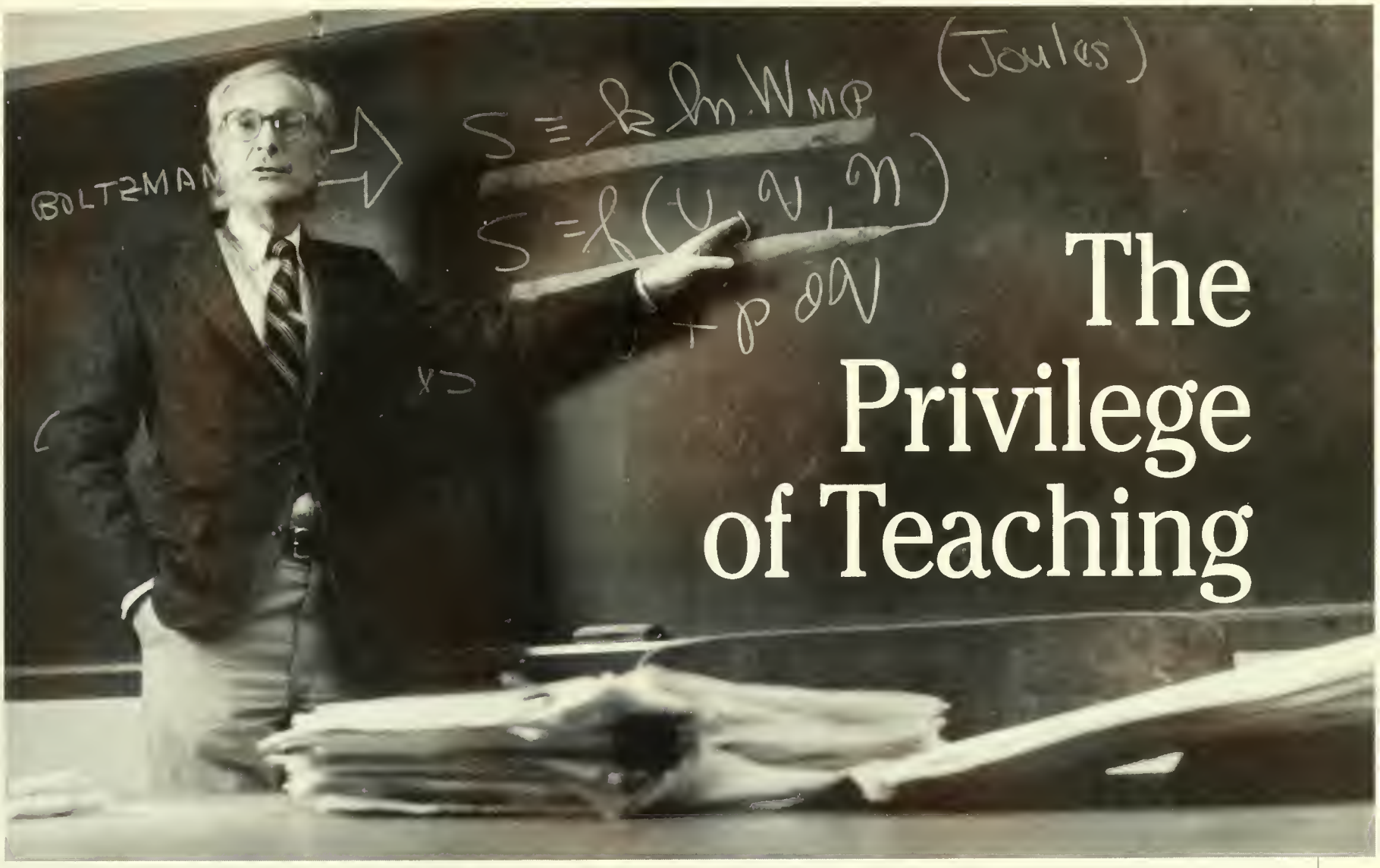
We must also vigorously seek to improve our societal view of engineering. Recently, when a light bulb in my hotel room needed to be changed, I called housekeeping and was told, "Our engineer will be there right away." That does not match my image of engineering.

Celebrate Diversity of Cultures

As a nation—and as a profession—we must recognize the extraordinary opportunities that exist in global alliances. We must teach our students to appreciate the beauty of diverse cultures, just as the brilliance of a tapestry comes from the blending of many colors of thread. And we must emphasize the importance of learning languages in our increasingly global economy.

We must respond to these exciting challenges; too much is at stake to let these opportunities pass. We need to pave a path for the next generation, giving them hope and high aspirations. The job before us will require enormous energy and leadership. And there is no time to lose. As the Red Queen says to Alice in *Through the Looking Glass,* "Now, here, you see, it takes all the running you can do to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

Apelian is provost and Howmet Professor at WPI. This article was excerpted from his Alpha Sigma Mu Lecture, presented at the annual conference of the American Society for Metals in Pittsburgh on Oct. 18, 1993.



The Privilege of Teaching

PHOTOS BY JANET WOODCOCK

It was an accident that got mechanical engineering professor Jack Boyd into teaching, but a natural talent and a deep-seated love for students has kept him at it for 35 years. Now, on the eve of his retirement, he shares his thoughts on education and WPI.

BY RAYMOND R. BERT '93

The description on my schedule sheet for the spring of 1990 reads simply—ES3001: Stat. Dev. of Class. Thermo.; Instructor: Boyd, J.M. (ME). Nowhere on the sheet is there any hint of just how different this class will be from all the others I've taken or will eventually take.

Enter an older man, perhaps in his late 50s, with gray hair, glasses and a conservative jacket and tie. Speaking in a clear and direct style, but with an inflection that reminds one of a storyteller, he outlines the mechanics of the course and distributes the first of many typewritten handouts—complete with some god-awful handwriting.

"There will be no exams until the end of the course," he says to his mildly stunned audience. "The bulk of the work will be in the form of group projects and reports on those projects. The emphasis of my class is on gaining functional literacy. I'm not concerned that you remember everything off the top of your head, but I am concerned that you know how to work out a problem from start to finish and understand what you've done along the way."

Halfway through my sophomore year, I'm just beginning to get comfortable with learning the blood and guts of mechanical engineering. Now I'm going to learn a new way to learn, as well. Thus am I introduced to Jack Boyd.

Teaching, and showing budding engineers how to learn, is what John M. Boyd does best. As a professor of mechanical engineering for 35 years, the last 28 at WPI, Boyd has helped guide thousands of students through the learning process. He is widely respected (if often disagreed with) for his teaching methods and for his honest opinions about education.

Boyd says his own education and self-discovery during his college years were instrumental in developing the philosophies that have shaped and guided his career. He took me on a walking tour of that stage of his life, pausing frequently to make note of curiosities and the alternate routes he took along the way.

Born and raised in Youngstown, Ohio, a poor steel town, Boyd did not drift naturally into college after high school. "I went to work for the Ford Agency as an apprentice mechanic," he recalls. "It didn't take me too long to realize that it was not such a good idea. I decided then to go to college. At $100 a year, Ohio State was the only place I could afford."

Enrolling initially as an electrical engineer at the 25,000-student university, Boyd felt a bit lost in the hugeness of the school. "Can I tell you a story?" he asks. "I started out my first semester with no idea what I was doing. I was given a schedule to fill in my classes. So I started filling them in—one at 8 o'clock, one at 9, one at 10, 11, a break for lunch, 12:30, 1:30—eight courses in all." He laughs at the memory of his naivete.

He straightened that out, but eventually switched out of electrical engineering, intimidated by what he saw as the superior knowledge of many of his peers, who had mastered the language of the field. "Looking back," Boyd notes, "that was probably my first encounter with the notion of a distinct difference between knowing facts and jargon and truly understanding concepts."

Starting an example problem during a lecture in his thermodynamics class, Boyd, as nsual, begins with a complete statement of the first law of thermodynamics. After detailing certain specific conditions and assumptions, he reduces the lengthy expression to a much shorter and simpler equation.

"This expression," he says, "is also called the Bernonlli equation. Now you'll see people approach problems all the time by starting off with this equation, because these are very common conditions. Bnt ask someone what the Bernoulli equation is—its essence, where it came from—and often they won't know, because they don't start at the beginning. Make a slight change in the assumptions and they don't know what to do. Now you know." Still do.

Electrical power systems' loss was thermodynamics' gain, as Boyd graduated with a bachelor's degree in mechanical engineering in 1952. He quickly landed a job with General Electric Co.; as before, though, his gut told him it wasn't right.

"I started in June," he says, "and I literally walked in the door and knew. I quit that same August." He was subsequently drafted and spent two years in the U.S. Army. ("I reached the illustrious rank of Pfc.," he notes wryly.) Discovering he could get out of the service a little early to go back to school, Boyd enrolled at Ohio State, this time as a graduate student.

"I was hired as a research assistant for a heart valve project, but the grant was pulled," he says. "So instead, I became a teaching assistant for a thermodynamics class. As it turned out—you have to understand my whole career has been based on a series of accidents—the professor had a heart attack and I was forced to teach the class."

Thrown in cold, Boyd quickly made a major discovery: "I loved it. I was terrified, but I loved it." Testimony to his gift for teaching was his appointment in short order to a position as a full-time instructor while he was still enrolled in graduate school. "Of course," he adds, "as a result it took me 10 years to finish my Ph.D."

After earning his doctorate in 1962 and receiving a promotion to assistant professor, Boyd married; soon after, he and his wife decided to move nearer the East Coast. "I looked at several schools, but had never heard of WPI," he says.

A friend of his at the University of Massachusetts wrote to Donald Zwiep, then head of WPI's Mechanical Engineering Department (and now department head emeritus), telling him of Boyd's availability. On a visit to campus, Boyd also met a few other young professors, including Hartley Grandin Jr. and Raymond Hagglund, both of whom are still on the WPI faculty. Boyd was impressed enough to accept a position as an associate professor in the department. But that is not to say that he liked everything about the program as it was then run.

Going through the archives of Newspeak, *WPI's student newspaper, one day, I came across the May 8, 1984, edition. A front-page article headlined "The Great Debate" described a debate between Boyd and William Grogan, then dean of undergraduate stndies. The two held opposing views on the direction the WPI Plan should take.*

The striking part is not the article, but the accompanying photograph of the combatants (above). While his opponent is pictured in a fairly neutral posture, Boyd, leaning forward and jabbing his fingers toward his chest, is obviously loudly voicing a point.

The picture conveys energy, fire in the belly. It depicts a man who cares deeply, a man who is committed to a vision of excellence, and a man who will fight to keep it from being compromised. Call me biased, but I'll bet he won.

What had been left out to this point in our conversation was a major—perhaps *the* major—turning point in the self-discovery of Jack Boyd. This kind of dramatic revela-

tion—a singular, seemingly innocuous event that forever changes a person—is supposed to happen only in the movies. Yet here he was describing one vividly as he pulled a well-worn book from a shelf next to his desk.

"During my graduate student days at Ohio State, I had an epiphany," he says. "See, I had made good grades simply because I worked my tail off. But I had little confidence that I could do anything. Then, wandering around a bookstore one Saturday, I came across this book, *Lectures On Physics* by Richard Feynman—a Nobel Prize winner, incidentally. On the very first page was a picture of Feynman playing the bongos. I found it utterly fascinating and bought it.

Boyd talks with Philip Muller '94. In his teaching, Boyd aims to give his students a "functional literacy."

"I took it home and started reading it. I thought, 'My God, I can understand this!' That same morning I began to re-educate myself. This is where you start, these are the assumptions—that's the way I teach. That's how you understand."

That is the experience Boyd brought with him to WPI. In terms of education, he'd seen the good and the bad. Now, in his opinion, he was being introduced to the ugly. "Here was a school of only 1,400 men that was highly structured and rigid—even more so than Ohio State," he says. "I became aware rather quickly that there was a growing dissatisfaction with the rigidity—and even sterility—of the curriculum."

The thrill of learning and understanding he himself had felt led him to want the same for his students. He wanted them to be swept up in the wonder and the challenge of it all. The development of his teaching style was born of that experience.

While talking to Boyd in his office one day, we were interrupted by a pair of students knocking on his door. As they posed their question about the latest project in Boyd's thermodynamics class, it occurred to me that the scene unfolding before my eyes, though unremarkable, was so typical of the man. As he conferred with the students, he displayed the same air of stern sagacity and fatherly kindness that I remembered so well.

The crux of the students' inquiry was how to improve their initially rejected report to a level of acceptability. "What do we do to fix this?" they asked. Boyd responded simply, "Do what needs to be done."

The answer was so simple, so fundamental, that to ask for clarification would have sounded foolish. The students nodded and left. Surely such an off-the-cuff remark was not intended to say as much as it did, but in six words Boyd explained much of the learning process as he professes it. Professors may teach, but students must actively learn to think for themselves.

"I was unhappy with the curriculum here," Boyd says about his early days at WPI. "I shot my mouth off a lot. As a result, I joined a group appointed by then President Storke to look into changes in the way we educated engineers."

The committee's efforts were to lay the groundwork for the WPI Plan. Boyd says the members went back to the faculty and asked to be elected as a planning committee to make it clear that it would be the professors, not the administrators, who would shape the new curriculum that the faculty would ultimately have to implement. Of the exhaustive work of this committee of six, Boyd simply exclaims, "It was the most incredible experience of my professional life; what an adventure!"

Debating and proposing and revising for endless hours, the committee eventually conceptualized the Plan. From an academic calendar based on seven-week terms, to the required projects, to the competency exam, the curriculum underwent radical changes.

"The philosophy we set forth was that the minimum amount of time spent doing projects should be 25 percent," Boyd recalls. "The idea was to learn all about learning and about your discipline before undertaking the Major Qualifying Project. In many ways we tried to emphasize the general over the specialized, to ensure that everyone had a proper grounding in the fundamentals."

With the Institute adopting an educational philosophy much closer to his heart, Boyd began to fashion each of his courses into a mini-Plan, replete with independent reading, group projects and all-or-nothing competency exams. He has stuck to that form to this day, demanding that students leave his class with a solid understanding—a functional literacy—in whatever area he was teaching.

"I'm not a very good mechanical engineer, in the traditional design sense," Boyd tells me one day. "No kidding. I'm not very bright. But that's what helps, because I've fallen into all the same pits my students do." He is proud of his teaching, a fact as clear as his passion for it.

That passion is also what makes him a stickler in the classroom. There are no C's in Boyd's courses. You must pass one exam just to demonstrate your functional literacy. For that you earn a B. Pass another, more difficult exam, and you earn an A. And when he says you must earn a B on that first exam, you will not pass the course until you do. Yes, your error may have been a momentary oversight, but it may also indicate a misunderstanding of a basic point. But you may also take the test again; in fact, you may take it several times, if you need to. No matter that it's two terms later and you are no longer enrolled in the course; show Boyd that you know your stuff and you'll pass.

By the end of Introductory Fluid Mechanics I knew Boyd fairly well, having been to his office many times to talk about class projects. He always managed to be helpful

without shifting the burden of understanding away from me—a fine line he walked with apparent ease.

Having already passed the competency exam for my B, I stopped by to pick up the second exam—the one that would determine if I would receive an A in the course. Pulling my test out of the stack, Boyd glanced over it and handed it to me almost apologetically. He explained that though most of my analysis was correct, there was a basic error in one of my assumptions.

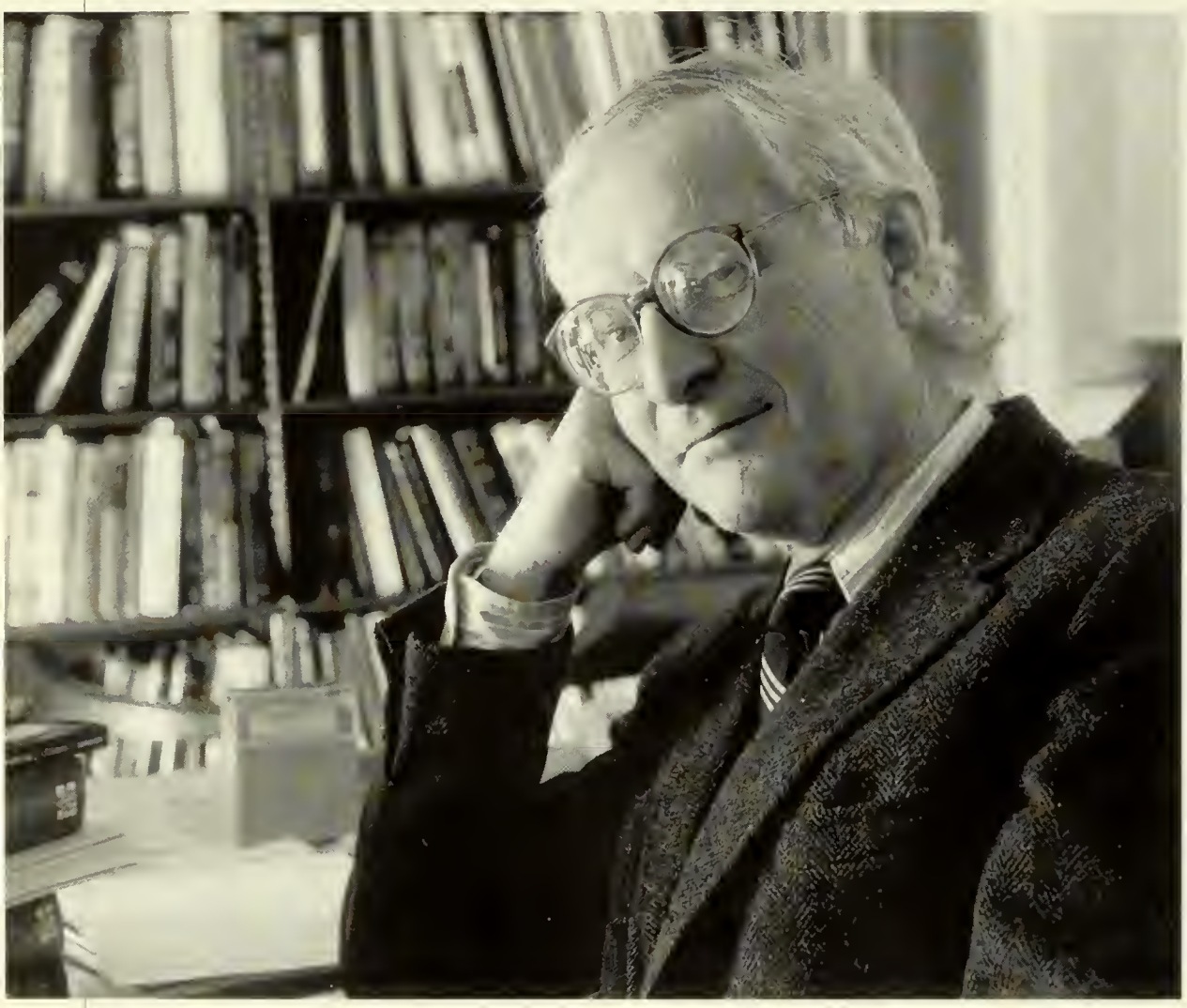
"I know it was probably inadvertent," he said of the sign I had reversed, "and I wanted to overlook it, but it involved too basic a principle and I couldn't." Uncompromising. Fair. Exactly what I would expect from him. I had made a similar error in the "A test" for the thermodynamics course. So my record shows two B's from Jack Boyd, which represents more learning than took place in any other course I took, regardless of the grades I received.

Boyd is not liked by some students for what they see as his unyielding attitude. And there may well have been instances where he was a little too stubborn—too dedicated to his cause. But glance at the course evaluations filled out by his students and you will see that he is held in high esteem by the vast majority.

For every student with a distaste for his style, there are five who wildly endorse his methods, which kept them up until all hours of the night, because people learn in his classes. Put aside Boyd's own protestations of being "not too bright," because the students know the real story.

Near the end of my sophomore year, having nearly completed my second course in the Boydian method, I received a notice requesting nominations for WPI's Trustees' Award for Outstanding Teaching. Knowing several other students who would also feel that Professor Boyd deserved the honor, I began to fill out the form.

It was then that I noticed that the nomination form included a list of past winners and a reminder that those winners are not eligible for future awards. There, near the top of the list, was: "1976...Jack Boyd." During my junior year, Boyd was named Best Professor in the first campuswide poll of students conducted by the student newspaper. It was an honor he would capture again the following year.



Over the years, Boyd's passion for education and for WPI have led him to repeatedly question the school's commitment to the ideals of the Plan. He raised his voice against the elimination of the Competency Exam and the return to more standard course distribution requirements. He is raising it again as WPI considers what's been dubbed "Plan II."

As he talks about these battles, some of the bitterness born of years of knocking hard against the administrative wall comes out. "First of all," he says, "what we need is for the faculty to come together and be fully invested in this new plan. At the same time that the original Plan was being formulated, we put together a faculty governance system. We had, at that time, a cohesive faculty being. We do not have that now."

In an annual report he wrote for the provost and the head of the Mechanical Engineering Department, Boyd voiced similar sentiments: "We desperately need an educational study by a deeply committed elected faculty committee—with no administrative members." In that report, Boyd also presented a critique of the current system and a proposal for WPI to break the mold again in academic innovation.

Shaking his head, Boyd laments, "It's gone. The excitement, the aspirations to be the best. The Plan was originally designed for up to 1,600 students, but it was used as a marketing tool to nearly double the school's population. The competency exam was abandoned in 1986, and engineering schools today are still too closely linked to vocation. We tend to train technicians rather than educate technologists."

As he speaks about the problems he sees WPI facing in the coming years, Boyd seems tired. He's fought this fight once before, and he's not prepared to do it again two decades. later. Asked hypothetically if he would answer a call to help shape Plan II, he says no. Professor Boyd will retire at the end of the current academic year.

Two years after my last class with Boyd, we met in the hall of Higgins Laboratories. We hadn't spoken in quite a while, since my interest in materials science had taken me away from his field of expertise. He inquired as to the progress of my studies, and I told him that I had recently decided to add a second major in English. He seemed fascinated by the combination and asked if he could see my major project for the English degree when it was complete.

It was a brief conversation, but it left a smile on my face. For all of

LYLE WIMMERGREN

Left, Wimmergren on the Navajo reservation in Arizona. Below, Navajo children dressed to learn about traditional tribal dances.

with NCAIED. He says Indians come to the center to learn about business from successful Indian businesspeople in the company of other prospective business owners. They can participate in workshops and programs on all aspects of business ownership—from identifying a need to establishing an employees' credit program.

"They stay until they become good enough to fly on their own—up to two years," Wimmergren says. "During my seven months at the center I worked with 12 American Indian volunteers who had experience—and often college degrees—in marketing, human relations, finance and other disciplines."

As a volunteer at the center, Wimmergren assisted with the implementation of aspects of its mission statement by working to develop and increase the region's Indian-owned and managed businesses, enlarge the Indian work force, and help those on the reservation forge a more secure future by establishing business relationships between Indian enterprises and private industry. He also helped set up an incubator system for new businesses and wrote *The Entrepreneur's Business Development Primer for Starting a Small Business* to enable Indian people to learn at their own pace about marketing, finances, human relations, and other aspects of business ownership.

"NCAIED's ultimate goal is to help tribes reduce their dependence on federal and state welfare assistance by teaching them to organize their resources, adopt sound management techniques, and become economically viable on their reservation," says Wimmergren, who notes that the foundation for success already exists.

"Native Americans in the Southwest own land that contains valuable resources. Coupled with the tourist industry (which offers opportunities to manufacture and sell Native American products) and the tribes' own need to provide goods and services for themselves, the Indians have the potential to achieve a self-sustaining economy and, ultimately, a higher standard of living."

The problem, he says, is that the tribes often live in isolated areas where running water and electricity aren't available, so they don't know what tourists need or expect. "They have to be eased into this awareness; that's one of the functions of the center—to introduce Indians to the world beyond the reservation, the world from which much of their business will come."

The key to success rests with individual members of the tribe—not outsiders, says Wimmergren, who with his wife will continue to work with the center and with the individuals they've gotten to know in the communities it serves. "If the Indian is going to be better off it will be because of Indian efforts and that means starting their own businesses. We want to help them as much as we can."

"Long Worcester" Song

Words and Music by
H. W. ADAMS '04

Tempo di Marcia

Alma Mater W. P. I.

WILLARD HEDLUND '10

1. Dear Worcester Tech our Pol - y - tech, our praises ring to thee, To Al - ma Ma - ter,
2 As years roll on, and changes bring To all things great and small, We still will thee in

good and true We pledge our loy - al - ty. Long have we felt thy guid - ing hand, Thy
reverence hold, We'll greet thee one and all. In accents which no one may doubt, In

teachings broad and free, With praises loud in every land, We'll show our love for Thee
terms so strong and bold The world will know thy worth to us In - creases man - y fold

REFRAIN

OLD TECH

R. H. GODDARD W.P.I. '08

"WORCESTER"

Arranged by
Clifford Fowler Green

Andante Maestoso

Rally Round the W. P. I. Flag

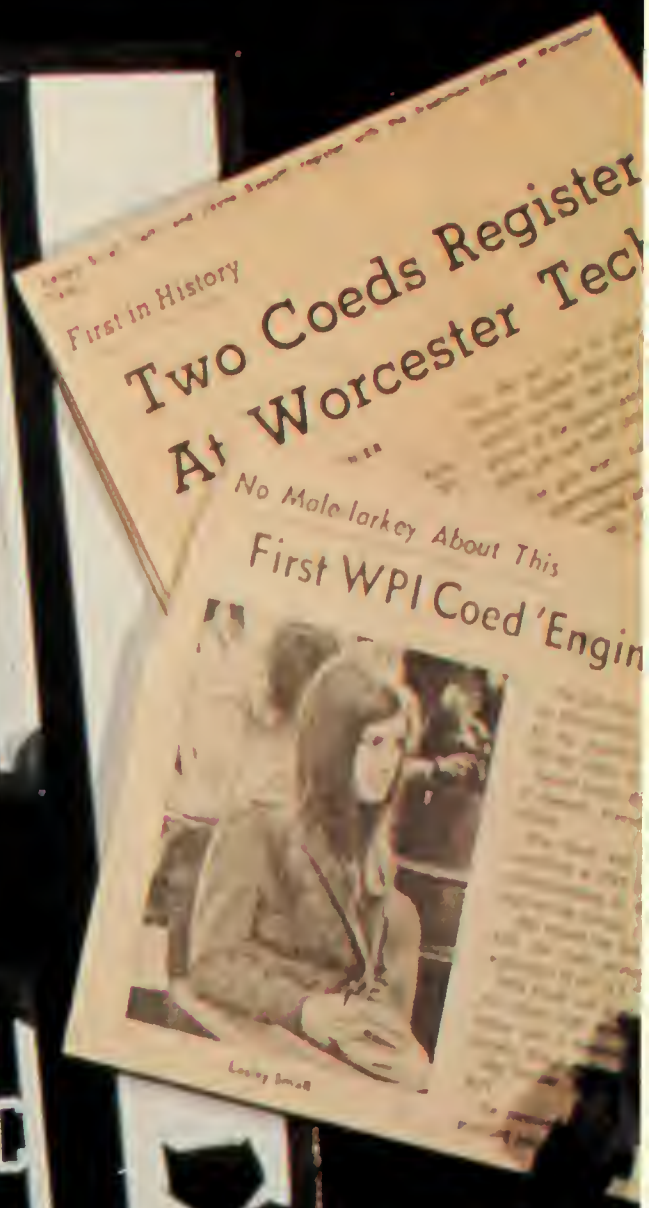
WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

SPRING 1994

First Stud. Govm't Pres.

First Coeds



First Homecoming Queen

First Hall of Famer

Memories of a Quarter Century

Celebrating 25 Years of Women at WPI

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Cover: Images from the first 25 years of women undergraduates at WPI. The "firsts" pictured on the front cover are, clockwise from upper left, Denise C. Gorski '75, first woman to be Student Government president; Jayne Rossetti, left, and Leslie Small Zorabedian '72, the first two women undergraduates; Suzanne Call Margerum '81, the first woman inducted into the WPI Athletic Hall of Fame; and Judy Bagdis Largesse '77, the first woman undergraduate to be chosen Homecoming Queen. Photo by Janet Woodcock. Story on page 12. **Opposite:** "The Rainmaker," a 12-foot acrylic sculpture that dominates the concourse of the newest casino at the Mashantucket Pequot's Foxwoods Casino and Resort in Ledyard, Conn. Photo by Janet Woodcock. Story on page 28.

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What They Dared to Do

By Joan Killough-Miller

Editor's Note: *Twenty-five years ago, WPI became a coeducational university. In coverage beginning on page 12, we look at how the college made that transition after more than a century as an all-male institution and hear from women graduates about their experiences during the past quarter century.*

The 25th anniversary of the arrival of women undergraduates was noted on April 16 with a special celebration on campus, "Women at WPI: Challenges and Achievements! Yesterday, Today, Tomorrow." We preface our coverage of this important milestone with a report on that event.

It was a time to shine, despite the pouring rain that soaked alumnae, students, faculty and staff as they scurried through cloudbursts between Alden Memorial and Riley Commons, reluctant to miss a word of a program 25 years in the making. The gathering was part reunion and all celebration.

With more than 500 women undergraduates currently on campus and 142 "freshwomen" expected in the Class of 1998, the Institute has come a long way from 1968, when the first two female undergraduates entered, noted Bernard H. Brown, vice president for student affairs. Brown praised the first women to integrate WPI, calling them articulate and self-confident. "They quickly became part of the solution to everything that faced them on campus," he said.

Helen Vassallo '82 (M.B.A.), head of the Management Department, moderated a panel discussion titled "Challenges and Achievements—What I Dared to Do!" She set the tone with poetry and quotations.

Blending past and present, student, professor and professional, the panel featured Holly Keyes Ault '74, assistant professor of mechanical engineering, Susan and Karen Daly of the Class of 1994, who are just venturing out into the world of graduate school and jobs, Patricia Graham Flaherty '75, owner of Graham Flaherty Information Systems, and John van Alstyne, retired mathematics professor and dean of academic advising.

"I hate pedestals," declared van Alstyne as he stepped down from the podium to address his audience on a level footing. His reminiscences and encouragement drew a standing ovation from his former advisees, who looked upon him as a counselor, father figure, and unflagging source of support.

Later in the program, "van A"—"a special name for a special man, full of fondness and affection"—was called back on stage to receive the 1993 William R. Grogan Award for exceptional service to WPI, which he was unable to accept in person last year. The award is named for his colleague and friend Bill Grogan, dean emeritus of undergraduate studies.

Top photo, keynote speaker Jane Shaw. Above, from left, panelists Bernard Brown, Helen Vassallo, Holly Keyes Ault, Susan Daly, Karen Daly, Patricia Graham Flaherty and John van Alstyne. Right, Maura Collins '91 takes part in a discussion.

PHOTOS BY JANET WOODCOCK

From left, Virginia Giordano FitzPatrick '75, Denise Gorski '75, Anne McPartland Dodd '75, Paula Fragassi Delaney '75 and Mary Jarvis '74 prepare to give reports on the roundtable discussions in which they participated.

Roundtable discussions on such topics as "Breaking Through the Glass Ceiling" and "Women's Issues at WPI" allowed for small-group interaction between different genders and generations. The groups discussed treatment in the workplace, balancing career, family and personal needs, as well as current campus issues: day care, equal opportunity in athletics, and mentoring and support for women, who still make up only 20 percent of WPI's student population.

The male-to-female ratio at WPI was seen as good preparation for the workplace, where women engineers can still expect to be in the minority. "But what are we doing to help *men* adjust?" one alum asked. As WPI students, women are being prepared to deal with men and let sexist treatment roll off their backs, participants agreed. "Perhaps we are overpreparing them," one woman commented, speculating that "WPI desensitizes us to comments other women may see as harassment."

During lunch, the assembly was addressed by WPI President Jon C. Strauss and keynote speaker Jane Shaw, president and COO of Alza Corp. and a 1992 recipient of an honorary doctorate from WPI. Shaw, who attributed her success in the pharmaceutical industry to a combination of luck and vision, charged members of the audience to be true to their value systems and remain optimistic. She projected a business environment in which women could be valued for their talent for teamwork and their tolerance for diversity.

"We are working against our conditioned instincts. The current shift in the paradigm of the business world provides opportunities for women to succeed without having to adapt to playing the game by men's rules."

—Jane Shaw

The program concluded with a videotaped presentation by Lora Brueck, WPI archivist and special collections librarian, who also arranged a display of photographs and news clippings chronicling the history of women at WPI. Her tape told the story through interviews and press coverage from the early days of coeducation to the current campus scene.

The last vestiges of those first 100 all-male years will soon disappear, Brown said. To hearty laughter and applause he announced that the urinals in the women's bathrooms of Sanford Riley Hall, where the first women undergraduates were housed, will be removed when the building is renovated in 1995. "They were home to flower pots, Halloween decorations, art deco drawings and many memories," he said. "I suggest we have one bronzed, appropriately labeled by our women, and placed in the archives."

Top, Paula Delaney presents John van Alstyne with the William R. Grogan Award. Bottom, Tina Gorski-Strong '84 makes a point during a roundtable discussion.

First Impressions

By Alfred R. Doig Jr.,
Vice President for
University Relations

JOHN FERRARONE

Al Doig with his twin sons, Ian, top, and Andrew.

It hardly seems possible that it has been almost a year since I joined WPI. The memory of my first day on the job, in late August 1993, is still fresh. It seemed as though I had hopped aboard a speeding train. The academic year had just begun; with it came the rapid pace of seven-week terms. That cadence was more than matched by the energy of an innovative and ambitious institution.

In the ensuing year, as I've taken part in the many activities, pageants and celebrations so familiar and so important to WPI alumni and friends, things haven't slowed a bit. Still, I've caught my breath enough to offer you my initial impressions of WPI. First, let me back up to the spring of 1993 when it became clear that I was being considered for the post of vice president for university relations. To secure the job, I decided I'd better make a full-speed-ahead, frontal assault on WPI.

As a first step, I thought that I should visit the campus and learn something about the institution from its buildings and facilities. I must confess, even though I grew up in Massachusetts and had been to Worcester many times, I had no idea where WPI was. But with a city map in hand, I made my way to Salisbury Street, up West Street, and into the visitors' parking area. Now I was ready to fulfill my two objectives: to walk through some academic buildings and to secure an undergraduate catalog.

From the beauty and well-manicured appearance of the campus and the high quality of the buildings and facilities, I gained a positive feeling for WPI's values and the sense of pride it takes in itself. The undergraduate catalog introduced me to the WPI Plan, an educational concept I found immediately attractive. I would make two more visits—one with spouse and children, and another to Gordon Library to bone up for my first interview.

Yankee baseball great Yogi Berra is reported to have said, "When you come to a fork in the road, take it." By the end of that interview, I felt I had arrived at a fork; I knew this was where I wanted to work. As good fortune would have it, President Strauss offered me the chance to take the fork and I accepted almost immediately.

"This is a wonderful institution, for which all graduates, parents and friends can be justly proud."

Since then, I've expanded on my first impressions. For example, I can tell those of you who have not been back to campus for some time to rest assured that your alma mater continues to be an outstanding institution still dedicated to helping students develop academically and in other dimensions. It has preserved all that is valuable in the private higher education system, such as classes taught by dedicated faculty in a supportive and intellectually stimulating environment.

You should also know that the WPI Plan, now two decades old, is still a model for others to emulate. Even now, this unique pedagogical approach is being studied by many other colleges and universities, including that institution on the Charles River in Cambridge known for its engineering program (a place where I worked for 13 years, by the way). With its emphasis on mixing practice and theory, the Plan is a more centered curriculum than you will find at any other university.

Among WPI's faculty and staff, the people responsible for upholding the Institute's tradition of excellence, there is an undeniable spirit of pragmatism that I find quite refreshing. It results in a no-nonsense, "let's-get-the-job-done" attitude. I think this attitude—and the success it has made possible—are part of the reason WPI's work force is so amazingly stable. This is also a warm and welcoming community. I've been received with genuine openness, as have the ideas I've brought with me.

My experience at WPI has truly exceeded my expectations. This is a wonderful institution, for which all graduates, parents and friends can be justly proud. It's an institution grounded on a fine tradition of academic excellence and programmatic innovation.

I guess a good indication of how I feel about WPI is that I know I would have enjoyed being a student here. But perhaps an even more telling measure of my belief in the programs and mission of this institution is how pleased and proud I would be were either—or both—of my sons to enroll here in the Class of 2012.

Unlocking the Puzzle of Object Recognition

During World War II, gunners on Navy ships were given cards depicting the silhouettes of allied and enemy aircraft. With these, they could learn to quickly distinguish between friend and foe as they watched planes fly against the background of a bright sky.

The science of object recognition has evolved significantly since then, driven forward in recent decades by amazing advances in the power and speed of computers. But despite all that progress, in some fundamental ways modern object recognition programs share surprising similarities to the system used by those sailors 50 years ago.

In most of the systems now in use, a computer attempts to identify an object by comparing its image to a collection of views of various objects stored in its memory in the form of computer models. Much like the sailors scanning the aircraft silhouettes, the computer must sort through all of the models in its memory—and all of the views they contain—looking for the one view that most closely resembles the image it sees. The process is time-consuming and requires expensive or unweildy computers.

To make their object recognition programs run faster, designers often limit the number of views through which the system must sort, notes David Cyganski, professor of electrical and computer engineering at WPI. "Most people recognize the impossibility of searching through all possible variations," he says, "so they try to incorporate into their programs some reduction in the dimensionalities of the search required."

But the simpler the search becomes, he adds, the higher the probability that the computer will make an incorrect match. If that computer is part of a missile guidance system or a targeting system on board a torpedo, a bad match could have disastrous consequences. For that reason, the U.S. military has long been interested in developing faster and more accurate ways to get a computer to recognize objects.

Toward that end, the federal Advanced Research Projects Agency (formerly the Defense Advanced Research Projects Agency) is supporting research by Cyganski, Richard Vaz, assistant professor of electrical and computer engineering, and John Orr, head of the Electrical and Computer Engineering Department, with $435,000 toward what is ultimately expected to be a three-year, $900,000 award. With the ARPA funds, the researchers will develop a totally new approach to object recognition—an approach that could be used in applications as diverse as navigation systems for autonomous vehicles and devices that automatically identify fingerprints.

According to Cyganski, the new system avoids the pitfalls of earlier systems by eliminating the need to create models that physically represent objects, and by dividing the process of object recognition into two distinct phases.

In the first phase, object models are created. This computationally intensive process is done off-line, yielding the models that are then used to identify objects in real time in a simple and quick procedure that requires little in the way of computer power. What makes this second phase so fast, Cyganski says, is the novel way in which the models are created.

"There is a parallel between our system and public key encryption systems used for security in sending computer messages," he notes. "In fact, our model-building process is really an attempt to create a decoding algorithm." Much like a traditional object recognition program, the process begins with a series of views of an object, showing it from a variety of angles. But instead of simply recording the information in those views, the computer mathematically transforms the data—in a sense, boiling the object down to its essence.

"There is a parallel between our system and public key encryption systems....Our model-building process is really an attempt to create a decoding algorithm."

JANET WOODCOCK

From left, Cyganski, Orr and Vaz are teaching computers to recognize objects in real time.

That mathematical essence is an equation that is analogous to a decoder. "The largest computers built in the early days of computing were created to break enemy codes," Cyganski says. "It took a tremendous amount of computer power. But once broken, a code could be decoded on a sheet of paper. Similarly, we expend a great deal of computer time off-line to 'break the code' and create these fairly simple models."

If the models are decoders, the messages they decode are the images of unknown objects. The object recognition system processes each message with the various object models in its memory. One of those

models will include the right code and reveal the message. "The message, simply, is 'here is what I am and this is how I am oriented,'" Vaz notes.

In fact, Vaz says, the actual products of the processing stage are two quantities. The first is a measure of how confident the computer is that the object it has selected is the right one. The second represents the object's orientation in space.

Because the object models are actually compact analytical representations, rather than collections of different views of an object, they take up far less computer memory than the models for traditional object recognition systems. In fact, the models for all of the targets a particular missile tracking system might encounter could be stored on a standard CD ROM disc. More important, a computer can process images with the models in a fraction of the time most object recognition programs need to identify an object, making it possible to recognize objects in real time.

The system that Cyganski, Vaz and Orr are developing differs in another important respect from traditional object recognition systems, Vaz says. "Most such systems can process only a certain type of imagery," he says. "For example, they work only for video images or sonar data. Our system will work for any kind of real or complex image data—from visible light, to synthetic aperture radar data, to thermal signatures—or for any combination of these. The algorithm doesn't change at all. The only thing that changes is the nature of the models."

The simplicity and versatility of the new object recognition system will make it ideal for a wide range of military and civilian applications, the researchers say. For example, it could be used in smart sensors that enable a missile to seek out specific targets, in weapons systems to help operators identify targets at night or in low visibility, in medical imaging systems to help doctors spot indicators of specific illnesses, and in parcel inspection systems to spot weapons or other selected objects no matter what their orientation.

With the funding from ARPA, which is being administered by the U.S. Army Research Office and its Night Vision Laboratory, the research team, which also includes three graduate research assistants, will use images of aircraft and military vehicles obtained by the Army using various imaging systems to develop the computer models. These will then be tested to see how accurately they can identify objects and determine their orientation, even when clutter and noise are present in the images.

At the same time, the team will be developing a standard method of determining the reliability of a given object recognition system under optimum conditions. This method will enable researchers to compare the potential performance of various systems and the confidence one can have in their ability to identify objects. "This is a critical part of machine vision research, but at the moment it remains a great unknown," Orr says.

JANET WOOCOCK

This Research Can Save You Money ...Trust Me

In his 1946 book *The Bomb and the Opportunity*, Henry Lewis Stimson wrote, "The only way to make a man trustworthy is to trust him; and the surest way to make a man untrustworthy is to distrust him and show your distrust." That simple axiom has proved true in all sorts of human interactions, from marriages to nuclear arms negotiations.

Now, thanks to a major study by the Construction Industry Institute (CII), it has been shown to apply as well to relationships between parties in construction projects, a realm where trust is often in short supply, says Guillermo F. Salazar, associate professor of civil engineering. Salazar, an expert on construction engineering and management, was a principal investigator on the study.

Founded in 1983, CII is made up of a cross section of large companies that purchase various types of construction services and the contractors that provide those services. Through special task forces that conduct research and action groups that implement the results of the research, the institute works to improve the cost effectiveness of the construction industry.

In 1989, Salazar was asked to join a task force formed to build on the work of another group that studied the terms and conditions used in construction contracts. "We looked at what they had done," he says. "While it was a good piece of work with practical applications, we decided it was not fundamental enough. It left unchanged the adversarial relationship that typically develops between parties in construction projects."

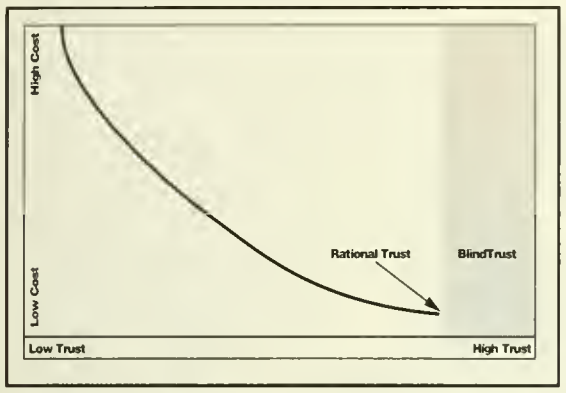
Salazar says the task force members decided they had to get to the heart of that antagonism, though how to achieve that goal was by no means clear. "We spent the better part of a year spinning our wheels, knowing that the problem was primarily one of attitude, but not knowing how to articulate it. Finally in early 1990 we started to see the light. The problem, we realized, is that we don't trust each other."

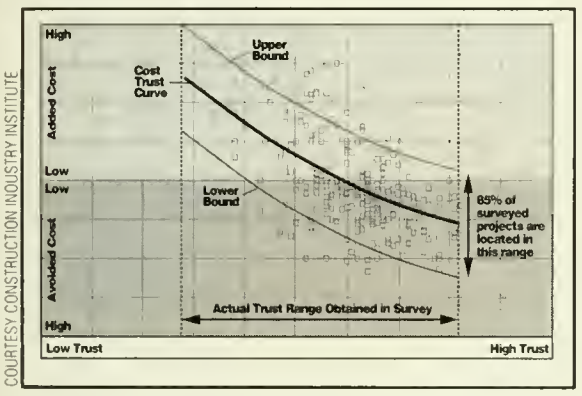
At one time, Salazar says, most construction agreements between owners and contractors were sealed with a handshake. Now they are likely to be outlined in lengthy contracts that are aimed as much at protecting the parties from the others as they are at defining each party's obligations and expectations.

"Everyone has come to assume that the construction industry should be a battlefield," Salazar says. "Everyone on the task force agreed that trust was the missing ele-

ment in many construction relationships, but they also suspected that it has to be that way, since otherwise you might lose money by exposing yourself. But we wondered, 'Is that really true?'"

Upon reflection, the task force agreed that intuitively the cost of doing business should decrease as trust increases, since by trusting one can dispense with the expense of defending oneself from the damage the other parties might do and realize the benefits of having parties working together constructively. They plotted a curve to illustrate this hypothesis. The curve shows project cost dropping steadily as trust increases—up to a point (see above).





COURTESY CONSTRUCTION INDUSTRY INSTITUTE

The top curve shows the relationship Salazar (opposite page) and his team expected to see between trust and construction project cost. The study confirmed the hypothesis, as the bottom curve demonstrates.

That point—the optimum project cost—they labeled rational trust. "Beyond that," Salazar says, "is blind trust. If you are too trusting you expose yourself too much, and if the other party takes advantage of that trust, it can cost you a lot of money."

Having laid out a hypothesis, the task force set out to determine how to test it. The first step was to define what trust means for those in the construction industry. The definition they settled on is "the confidence and reliance one party has in the professional competence and integrity of the other party to successfully execute a project in the spirit of open communication and fairness."

They also defined a set of 15 indicators that define where trust between parties can be observed during different phases of a construction relationship. And they developed a methodology for measuring the added costs (redundant efforts, cost of indecision, cost of defensive procedures) and avoided costs (money not spent because of the willingness of the parties to work together rather than taking defensive postures) associated with different levels of trust.

After a successful pilot survey in the summer of 1990, CII agreed to award WPI's Civil Engineering Department $176,000 to conduct a full-scale study. Salazar, with members of the task force, spent most of 1991 developing, testing and fine-tuning a questionnaire. Drawing on social science research on trust, on multiattribute utility theory, and on the considerable experience of the task force members—and with the guidance of an expert in questionnaire design—they carefully crafted questions designed to elicit the data they needed from CII members and several non-members.

"The problem, we realized, is that we don't trust each other. Everyone has come to assume that the construction industry should be a battlefield."

To distinguish their survey from the many others CII members receive each year from various task forces—and to make it more fun to complete—they computerized it. And in another effort to boost the return rate, each task force member called a group of targeted individuals asking them to send it back. A hot line was established at WPI for anyone who had questions about using the computerized survey.

As a result, 165 of the 317 surveys were returned, an unusually high response rate, Salazar says. Since several respondees reported on more than one project, the returns included 262 projects. The results were analyzed and plotted, and the resulting graph agreed remarkably well with the one the task force had drawn two years before.

"We feel the results of the research will allow people to move beyond the intuitive concept, with which most people would agree, that trust can lower your costs," Salazar says. "We've also developed a computer program that lets people see where their relationships with other contracting parties fall on the trust curve."

Salazar said the next phase of the effort includes additional research on measuring added and avoided costs, as well as additional studies on trust in different cultural settings. More important, it includes implementation of behavioral changes on the part of owners and contractors that will help them trust one another. These efforts are being undertaken by researchers at WPI and elsewhere in the United States and around the world.

Already, Salazar says, he sees a movement toward greater trust in construction relationships, a movement reflected in the growing tendency of owners and contractors to form partnership arrangements instead of traditional construction contracts. In part, he says, this is due to the economic pressures that are forcing companies to downsize and lay off technical people whose role was to check up on "the other side." But he says there is also a growing recognition that trust saves money.

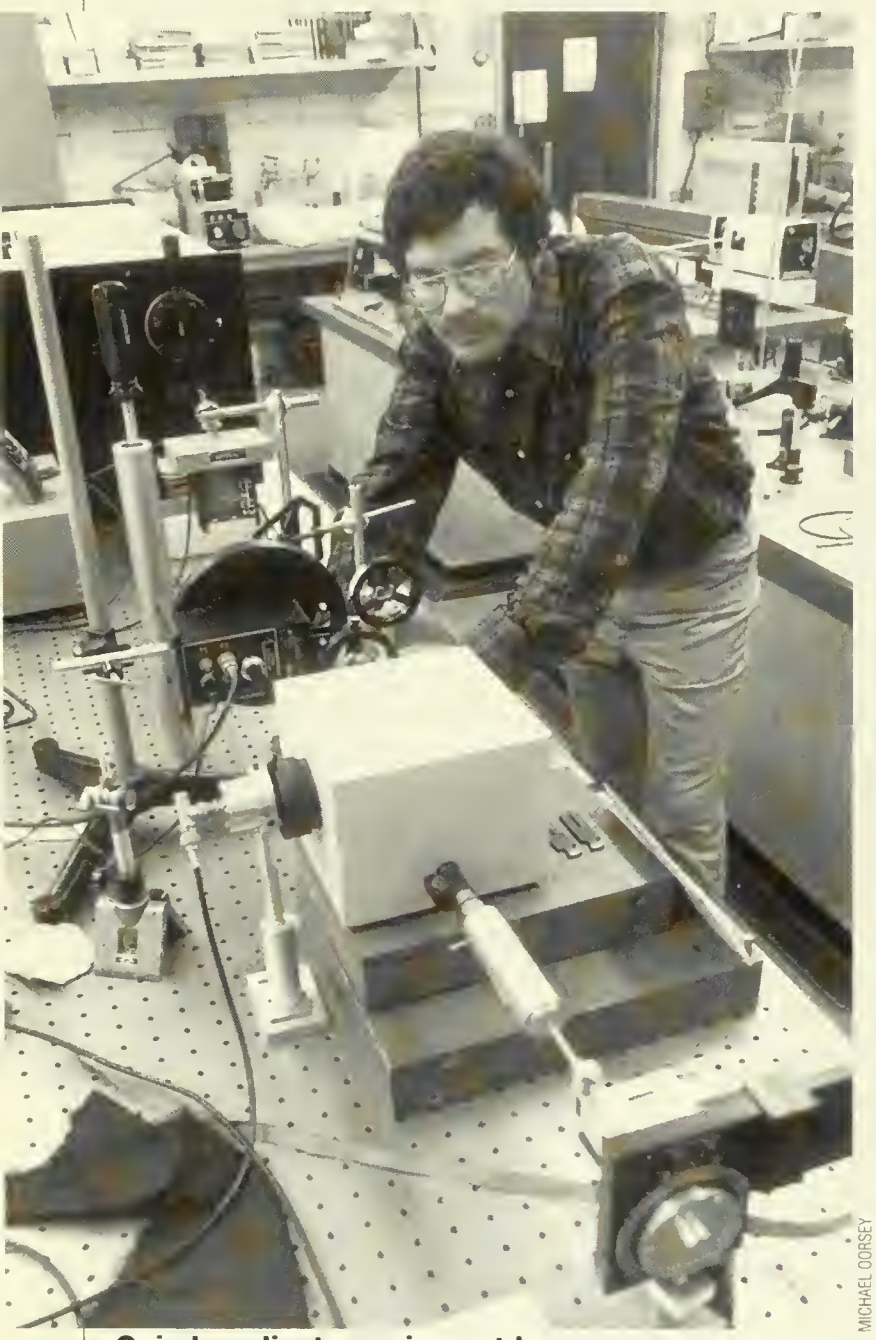
"All of the sudden this has become a philosophical movement," he says. "Things are changing, and people are saying, 'lets work in a different way.' I think our research has had an impact on this movement by showing people that while trust is not the only variable that affects cost, it impacts all of the other variables that can help them be more cost effective."

Understanding the Physics of Fiber-Optic Amplifiers

Since they were first introduced just a few decades ago, fiber-optic cables have become the dominant technology for delivering voice and data over long distances. Cables made from bundles of hair-thin glass fibers can carry far more information than metal wires, and that information can travel farther without amplification, making fiber optics ideal for handling the heavy traffic of modern telecommunications systems.

Despite their advantages, most fiber-optic systems have a weak link in the form of electronic amplifiers. When light speeding through an optical cable reaches an electronic amplifier, it must be converted to electricity, amplified, and then reconverted to light before it can continue its journey—an inefficient process that reduces the overall transmission speed of the system.

In addition, electronic amplifiers can handle only one signal or data stream at a time and must be reprogrammed each time the transmission rate of the cable is changed. In contrast, optical amplifiers, which transmit light in the same way as optical fibers, can handle multiple signals traveling at virtually any speed. For these reasons, along with the fact that they require less maintenance than their electronic cousins, telecommunications companies would like to replace all of their electronic amplifiers with optical devices.



MICHAEL OORSEY

Quimby adjusts equipment he uses to study the properties of optical amplifiers for fiber-optic systems.

Through a quirk of nature, scientists have discovered that the metallic atom erbium is perfectly suited as an amplifier for the newer 1.5-micron fiber optics being used in a new generation of transoceanic telephone cables. But the search is still on for amplifiers for the older 1.3-micron fiber optics in use in most telephone cables around the world.

One of the key players in this international quest is Corning Inc., the company that developed the first low-loss optical fibers that made the fiber-optic communications revolution possible. Corning recently enlisted Richard S. Quimby, associate professor of physics at WPI, in the search. With a grant from Corning, Quimby will use several new techniques he has developed in optical spectroscopy to test new materials produced by the company.

"One physical phenomenon we will be looking at is called clustering," Quimby says. "To make an optical amplifier, you first add selected ions to an optical fiber. In some glasses, these ions have a tendency to cluster together. While this can sometimes have a positive effect, usually it tends to quench the amplification."

In his laboratory, Quimby will also be testing the new glasses for an effect called excited-state absorption. "The basic mechanism of optical amplification goes back to Einstein's stimulated emission hypothesis of 1917," he says.

The hypothesis says that if a photon passes near an atom that is in an excited state, and if the energy of the photon exactly equals the difference between the atom's current energy state and a lower energy state, the photon will stimulate the atom to drop to the lower energy state, emitting its excess energy in the form of another photon. This is the same phenomenon behind the operation of lasers.

Interestingly, Quimby says, the photon that the atom emits is always identical in wavelength to the original photon. This is the reason optical amplifiers can handle multiple signals, as long as each signal is assigned a different wavelength.

Excited-state absorption occurs when the energy of the photon matches the difference between the atom's excited energy state and a higher energy level. When that occurs, the atom will absorb the photon. A material that exhibits excited-state absorption may not work as an amplifier, Quimby notes.

To test for these phenomena, Quimby exposes samples of Corning's new materials to light from a laser and then passes the light emitted by the samples—called fluorescence—through a spectrometer. He also measures how long the samples continue to emit light after the laser is turned off. If the fluorescence dies out quickly, it may indicate that the photons emitted by atoms in the sample are being dissipated before they can exit the material.

With the support from Corning, Quimby will be able to purchase needed equipment and provide partial support for a graduate student. He says that in addition to providing useful scientific results to the company, the funded work will enable him to explore areas of physics that are of interest to him. "I think this is a good example of how collaboration between universities and companies should work," he says. "There truly should be something for both parties. That's especially true these days, as companies are coming under increasing pressure to justify their budgets."

Casting Light on Lost-Foam Casting

Sand casting is an age-old technique for fashioning parts from iron, bronze, aluminum and other metals. In a process that has changed little over the years, sand mixed with binders that help it hold its shape is packed around a wooden form. The form is then removed, leaving a cavity into which liquid metal is poured.

During the last decade, a new casting technique has begun to give this traditional method a run for its money. Called lost-foam casting, it replaces the wooden form with a mold made from expanded polystyrene (EPS)—the plastic foam used to make coffee cups and coolers. Sand—without the binders—is loosely packed around the plastic mold and the hot metal is poured in, vaporizing the plastic and filling in the void left behind.

Though lost-foam casting was invented in the late 1950s, it has only been since 1981, when the patent on the process expired, that it has taken hold in industry. So far, automobile companies are the biggest users (all of the aluminum castings for the Saturn, for example—including the entire engine—are made with lost-foam casting), but the process is also being used to make everything from boat engines to tractors. It's esti-

mated that 40 percent of all castings will be made with this technique within the next two decades.

There are several good reasons for this, notes Satya Shivkumar, associate professor of mechanical engineering. For one, it is easier to make plastic patterns with injection molding machines than to fabricate wooden patterns. Because the molds aren't removed from the sand before the metal is poured, the process is easier to automate. And foam plastics produce fewer potentially dangerous gases when they are heated than do the binders used in traditional sand casting.

"You can also cast far more complex parts in one piece with the lost-foam technique," Shivkumar says, "giving you greater design flexibility." Plastic molds for parts that would normally be bolted together after casting can be glued together and cast all at once, he says. "At one company they can make a part in one piece that was formerly cast in 10 different pieces."

For these reasons, Shivkumar says, parts can be produced 20 to 40 percent cheaper with lost-foam casting than with traditional casting. But the process is not without problems. The interaction of liquid metal and polymer can result in defects unique to the lost-foam process. These include folds that can cause leaks and adversely affect pressure tightness.

Because lost-foam casting is a relatively new process, scientists do not yet have a good understanding of why these defects arise or how to prevent them. For more than a decade, beginning with his Ph.D. dissertation at Stevens Institute of Technology, Shivkumar has been at work gathering the experimental data needed to fill that information gap.

Much of this work has been supported, in part, by awards from General Motors—a major user of lost-foam casting—including a recent three-year, $150,000 research contract. The research has focused on a number of factors that affect the quality of castings made with the lost-foam technique. These include everything from the design of the gating systems that direct the molten metal into the molds to the shape of the tiny beads that make up the expanded polystyrene plastic.

Much of the work has focused on what happens to the foam plastic as it meets up with the liquid metal, Shivkumar says. "We've shown that the polymer is the key to the whole process. Most of the plastic does not turn immediately to a gas. Instead, it forms a gooey, viscous residue. We've done a lot of experimental studies and have created computer models to better understand how this and other degradation products form and how they are eliminated into the sand."

The faster these products are eliminated, the better the casting, he notes. In fact, folds and other common defects most likely form when the viscous plastic comes in contact with the rapidly cooling metal. A thin coating of a ceramic material normally applied to the plastic may absorb some of the molten plastic, Shivkumar says.

"There are a number of commercial coatings in use," he says. "We want to find out how well they work and whether we can improve them to make sure that the contact time between the degradation products and the cooling metal is as short as possible." Also under investigation are alternatives to the silica sand now used in lost-foam casting and other types of foam plastic that may vaporize faster and produce fewer fumes.

To study the various factors that affect the success of lost-foam casting, Shivkumar employs a variety of techniques. Thermocouples and pressure sensors inserted into a mold measure how the liquid metal solidifies. Instruments like differential scanning calorimeters and thermogravimetric analyzers measure the physical properties of the polymer. Light and electron microscopes are used to study the characteristics of the finished metal parts. By placing the plastic pattern against a glass window, one can even observe what happens as the liquid metal is poured into the mold.

Shivkumar says he hopes that his research will help provide the answers that will make the lost-foam technique attractive to a broader range of industries. "A lot of people are hesitant to use this process—and to make a major investment in new equipment—because of the lack of information. We hope our research will help them overcome that reluctance."

—Michael Dorsey

JANET WOODCOCK

Shivkumar, center, watches as Anthony M. Rodriguez '94, left, and Joseph E. Laskowski '94 pour molten aluminum into a foam plastic mold in WPI's Aluminum Casting Research Laboratory.

Fine-Tuning New Zealand's Fire Codes

New Zealand consists of four islands with a combined area about the size of Colorado and a population of more than 3 million. This nation, where people live in everything from huts to high-rise apartments, is a world leader in building regulation. But it wasn't always so.

Like many other countries, New Zealand had problems with its building codes; at one time there were 250 authorities responsible for implementing myriad bylaws and regulations that varied from area to area. The perception was that the codes were not only costly, but inefficient.

In 1983, after four years of evaluation and examination by educational and private agencies, a national performance-based building code was implemented to regulate and standardize building construction and maintenance and to significantly improve fire safety. In 1991 the code became law.

With support from the University of Canterbury in Christchurch and the New Zealand Fire Protection Association, Mark E. Anderson '94, Andrew T. Cox '95, Peter D. Irelan '94 and Theodore D. Woehnker '95 examined New Zealand's building codes and identified challenges to their implementation. Paul D. Sullivan, a master's degree candidate in fire protection engineering, assisted with the project. Jonathan R. Barnett, professor of fire protection engineering at WPI, and Andrew Buchanan of the University of Canterbury were the co-advisors.

In the spring and summer of 1993, the students interviewed representatives of New Zealand's Building Industry Authority, the New Zealand Fire Service and territorial authorities, as well as fire protection engineers, architects, designers, contractors, insurers, and building owners and managers. They found that while enactment of the code has enabled New Zealand to eliminate confusing local bylaws yet leave the code reactive to varying geographical needs, problems arise in three areas: paperwork, code compliance and liability.

The students determined that education about the codes would be significantly improved by implementing a national training program and by standardizing paperwork, among other improvements. They recommended that a national governing body be charged with creating a uniform set of national procedures. Government officials would train representatives from each local authority who would then educate other individuals, such as members of the city council, contractors, designers and insurance personnel.

They also recommended that paperwork be standardized at the national level and computerized, that individual authorities create site-specific instructions for each territory, that a peer-review system be implemented to assist local authorities in evaluating innovative designs to ensure that health and safety requirements are met, and that periodic seminars be held to provide practicing fire protection engineers with in-depth training on FPE concepts.

Above, from left, Cox, Anderson, Professor Barnett, Sullivan, Woehnker and Irelan in New Zealand, where they evaluated that nation's fire codes. Opposite, American Forests' Jill Mahon with, from left, Woo, St. Marie and Fernandes.

"New Zealand has taken a great step forward and committed itself to a new era of building regulation," the students wrote. "By implementing a performance-based code, the country is acting as a world leader in building controls."

Their project won for Anderson, Cox, Irelan and Woehnker WPI's 1993 President's IQP Award. They traveled to New Zealand as part of WPI's Global Perspective Program (see *WPI Journal*, Spring 1993).

Saving the Urban Forests

No one could ever accuse Jose F. Fernandes '95, Daniel D. St. Marie '95 or Phillip K. Woo '95 of not being able to see the forest for the trees. Last fall the students, working out of WPI's Washington, D.C., Project Center, inventoried and evaluated all public and privately owned trees within three demonstration sites in the city of Frederick, Md. The project was completed in cooperation with Jill Mahon of the American Forests' Urban Forestry staff and was advised by Kent J. Rissmiller, assistant professor of social science and policy studies, and Hossein Hakim, associate professor of electrical and computer engineering and WPI's global program officer.

Known as "urban forests," trees within cities provide wind breaks in cold weather and cool canopies in the heat of summer. Unfortunately, urban forests are in decline. The result is an "urban heat island effect" in which cities are, on average, as much as 12 degrees warmer than the surrounding countryside. The higher temperatures, in turn, result in greater energy consumption to cool buildings and in an increase in air pollutants associated with generating that energy, among other problems.

To save urban trees, the federal government has instituted the Climate Change

Action Plan, which will mandate the planting of appropriate trees. The plan will become law in the year 2000. In anticipation of this plan, American Forests and the Environmental Protection Agency, in cooperation with other government and nongovernment agencies, is putting into effect a Cool Communities program at eight pilot sites. The program is designed to implement strategic tree planting and surface-color lightening in cities and monitor the effects of these changes on energy consumption. The goal is to lower urban temperatures.

Fernandes, St. Marie and Woo analyzed the condition of Frederick's urban forests and evaluated the benefits of their shade to the community. "Their work was instrumental in developing mapping and evaluation techniques for the Cool Communities program," says Mahon. "These techniques can also be used for future regional and municipal planning."

The students also proposed planting new trees to maximize the benefits of urban forests, evaluated the use of Geographic Information Systems and aerial mapping, and created a public awareness campaign to increase support for the Cool Communities program.

"These students were able to learn and apply that new knowledge each day on the job," says Rissmiller. "And in applying it, they made a genuine contribution to the Cool Communities program. Their work will be the model for other communities working to preserve urban forests."

Helping the Sierra Club Save the Environment

The Sierra Club was created in 1892 by a group of outdoorspeople and conservationists to protect the Sierra Nevada and other West Coast mountain ranges. In the 1950s the nonprofit agency gained national recognition after members successfully defeated a plan by the government to build two dams that would have flooded the Grand Canyon.

Today it has 500,000 members nationwide. With more than $40 million in income, the club is a major force in environmental activism and conservation. But like many other nonprofits, it has seen contributions decline as potential donors' incomes and resources have decreased.

In the first-ever collaboration between a student team and the Sierra Club, Scott P. Krause '94, Kevin M. McBride '94 and James H. Phelps '94 assessed emerging technologies used for fund raising to determine which would be most effective and efficient for the agency. James P. Hanlan, associate professor of history, was the advisor. The students completed their IQP at the club's San Francisco headquarters under the direction of Kathryn Morrelli, head of fund raising for the organization.

As a result of their research, Krause, McBride and Phelps recommended that the Sierra Club develop a computer bulletin board network in conjunction with its chapters for use in fund raising, activism and communication between members. The network could also be used to educate the public on the organization's mission, they noted. The system could facilitate the exchange of alert bulletins, newsletters and electronic mail at a fraction of the cost of mailing the information.

The students also recommended that the club consider establishing a network that would enable the organization to distribute promotional computer software to bolster its fund-raising efforts and allow for the institution of electronic funds transfer as a donation option. And, they said, the club should create an educational videotape that could be used to solicit high-level and large-gift donors.

The Sierra Club followed virtually all of the students' recommendations. It has established a computer bulletin board that lets staff and volunteers at San Francisco headquarters access up-to-the-minute conservation data, media releases, club activities and other information. The club is investigating the feasibility of adding bulletin boards that members and supporters can access.

A new Sierra Club screen saver—software that displays graphics on a computer screen when the computer is not in use—was developed in conjunction with Microsoft Corp. It displays beautiful natural scenery and includes a form that purchasers can use to join the Sierra Club. And the club installed a new computer system that will make their personal fund-raising efforts more efficient.

"One of the joys of working with this group of students was watching their increased appreciation of collegial organizations," says Hanlan. "Much like a college faculty, the Sierra Club functions as a group of colleagues with independent expertise in a variety of specialized areas. Staff members share ideas, cooperate in informing one another, and appreciate complexity and diversity of views.

"At first, our students found this frustrating. They wanted a hierarchical organization with clear lines of command. As they worked on the project, however, they came to appreciate the strengths of mutual exchanges of expert opinion. They saw the way in which a seeming lack of hierarchy can foster thought and creativity."

—Bonnie Gelbwasser

Pioneers!

For more than 100 years, WPI closed its doors to women undergraduates. But a quarter of a century ago, with a vote of the Board of Trustees, all that changed. Here is the story of the Institute's first 25 years as a coed university and of the experiences of the pioneering women who forever changed this institution.

By Joan Killough-Miller and Bonnie Gelbwasser

We have been receiving an increasing number of serious inquiries from scholastically qualified young women who could benefit from the quality of education Worcester Tech provides. With a much higher percentage of women preparing for careers in engineering or science, it was inevitable that this college would open its doors to the ladies....

"Worcester Tech's founder, John Boynton, recognized that the school would have women students someday when the trustees felt the time was appropriate. That time is now."

—President Harry P. Storke,
Feb. 14, 1968 [quoted in *Tech News*]

With those words, announcing the decision reached by the Board of Trustees four days earlier, President Storke set the stage for WPI's first 25 years as a coed institution. At the same time, Storke announced the inauguration of new academic programs with courses in chemistry, physics and math that he said "should be of particular interest to women."

Below, a 1925 view of what a coed WPI might be like. Marietta Fletcher, opposite page, was one of two women on WPI's early faculty. The next female faculty member, Barbara Murphy, above, arrived in 1967.

Though the Institute passed its first 100 years as an all-male institution, its founding fathers never intended to rule out or ignore women. Ichabod Washburn, recognizing "the impossibility of providing for the contingencies in the future," gave the original trustees the power to change with the times. In his 1865 letter of instruction, John Boynton described a school for both males and females, but allowed the school to limit the privilege to "males only" if it found it to be "more advantageous to the community."

The privilege was indeed limited from the start. The Worcester County Free Institute of Industrial Science opened on Nov. 11, 1868, with Charles O. Thompson as its principal. Although the opening-day notice did not mention gender, stipulating only that pupils must be between the ages of 14 and 21, when parents asked about enrolling their daughters, Thompson pleaded lack of space. "We cannot receive any women without undertaking to instruct all competent women who apply," he said. "This we have not room for now. It is our purpose to throw the school open to youth of both sexes as soon as we can."

Ironically, Thompson didn't close the doors to female instructors. In fact, the Institute's first math instructor was his sister-in-law, Harriet Goodrich, who had been his assistant when he was principal of Arlington (Mass.) High School. She was succeeded the following year by Marietta S. Fletcher, who taught English, French and German for three years. After Fletcher left, the faculty remained entirely male until 1967, when Barbara F. Murphy became an instructor of chemistry. (A number of women did serve prominently in the administration through the years—see story, page 15.)

When we first started taking evening classes on campus I inquired where the bathroom for women was located. It wasn't! So my first professor made up a sign saying "WOMEN," which I put on the door of the men's room when I used it.

"I really don't believe WPI knew I was a woman until we came aboard on campus. We used to joke that WPI thought I was 'Aubrey,' not Audrey."

—Audrey Carlan '57 (M.S.)

Although female students took an occasional course or two at WPI through the years, the Institute's student body remained steadfastly male until the 1950s. It was then that a small group of men and women employees of American Optical Co. in Southbridge, Mass., eager to take graduate courses in physics, convinced WPI to sponsor the classes, which were taught at American Optical.

Eventually the Institute decided to create a formal graduate program in physics and the courses were moved to the WPI campus. Of the original students, only Audrey M. Carlan, a mathematical physicist in optical computing, and her husband, Alan, continued; in 1957 they earned the first two graduate degrees in physics awarded by the Institute. (By the end of the 1960s, three more women would earn graduate degrees at WPI.)

At the age of 26, Audrey made history—and not only as the first woman to receive a WPI degree and half of the first husband-and-wife team to walk across the stage at Commencement. She was also WPI's first pregnant graduate, giving birth to her first child six weeks after receiving her degree. Now the mother of three children, she is professor emerita of mathematics at Southwest College in Los Angeles and campaign manager for her husband's bid for California state assemblyman.

The girls stated that they are a little scared and nervous about entering a school that was previously all male....The young ladies were on campus for about one half an hour last week and were already causing commotion. Any student that went by wanted to know, 'Who are the girls?' This appears to be something our 'co-eds' will just have to get used to."

Tech News, *May 1, 1968*

Jayne Rossetti, left, and Lesley Small in 1968. Below, Audrey and Alan Carlan in 1957.

Because the Board of Trustees' decision to admit women undergraduates came so late in the 1967-68 academic year, there was little time to recruit female students. Jayne Rossetti and Lesley E. "Lee" Small, the only two women accepted for the Class of 1972, hailed from nearby towns—Hopedale and Spencer—where each was No. 1 in her high school graduating class. They would live off campus their first year, as there was no time to make provisions for them in the residence halls.

Rossetti says she and her classmate got an early taste of how they would be accepted by the male students. "In our orientation packets we all received a tiny dictionary," she says. "Under L was this poem: "'L' is for Lesley/and also for Jayne/They'll either leave pregnant/or else go insane." She says WPI's just barely coed status that year even came in for some ribbing from Janis Joplin during a campus concert.

It was a lonely time for these pioneers, who, as commuters, had difficulty integrating into campus life. Although she had been in all-male classes in high school, Small, now a database manager for Allen Rodman, P.C., in Malden, Mass., told the *Journal* in 1988, "I was shy, and I didn't want any special treatment. I just wanted to be treated as one of the students."

The next year 24 more women enrolled. Five were commuters, but the rest—along with Small and Rossetti—moved into converted quarters on the first floor of Sanford Riley Hall. Amenities such as shower curtains, full-length mirrors and window drapes had been added. The women's wing was set off from the rest of the dorm by a pair of fire doors at one end and—perhaps more formidable—"Ma Riley" (see story, page 18).

"I have wonderful memories of those early years with this very special group of women who really broke new ground and some early barriers for women at WPI," says Bernard H. Brown, vice president for student affairs who was then assistant dean of student affairs. "They were our resources for developing our first residence hall regulations for women—security and safety issues, sign-in policies, bathroom issues and needs, and visiting hours."

Even with the influx, the ratio of men to women was still 74 to 1. Jayne Rossetti left the Institute for personal reasons before graduation. After nine years as a weather forecaster with the U.S. Navy, she earned a bachelor's degree in computer science at Boston University and is now a senior engineer at Textron Defense Systems in Wilmington, Mass. In 1972, Small became the first woman to receive a B.S. degree from WPI. The next year, 15 more undergraduate diplomas were awarded to women.

Female enrollment grew slowly, but women students were still a visible minority. They went to the dining hall in pairs—or didn't go at all when the staring became too uncomfortable. Some wore miniskirts to class—though usually just once. And they all thought a lot about bathrooms—or rather the lack of bathrooms for women around campus.

"As a commuter my first two years, I became friendly with the female secretaries in each of the academic buildings," remembers Mary F. Polanik Sherman '76, a mathematics teacher at Grafton (Mass.) High School. "If there was a female secretary, that meant there was a ladies' room close by."

"I spent many hours in WACCC [the old computer center in the lower level of the library]," says Virginia Z. Ogozalek, who received her master's in computer science in 1985 and is now a computer science instructor at Worcester State College. "There was no women's bathroom in there. Women were supposed to walk outside—even in winter—and up about a million steps to the bathroom in the library."

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Keeping the Records and the Books

While WPI did not admit its first women undergraduates until 1968, women have played central roles in the administration since the Institute opened its doors 126 years ago. Two administrative offices, in particular, have been occupied by women for most of the Institute's history.

Bonnie-Blanche Schoonover

The "Bookkeepers"

With one exception, women have always kept the books at WPI. The books, in this case, are in the library, and two of those "bookkeepers" served for a total of 62 years.

Elizabeth Francis was appointed WPI's first librarian in 1896. Mary Liscomb served in the job from 1900 to 1902 and was succeeded by Cora Smith, who stayed for just a few months. The college then selected Emily Maud Haynes, sister of George H. Haynes, professor of economics and government. The choice proved prudent, for she spent the next four decades as head librarian.

Haynes, a native of Sturbridge, Mass., earned a certificate from the Drexel Institute Library School. She maintained the expanding collections and moved with the books and periodicals to Alden Memorial when that building was completed in 1940. She retired two years later.

Haynes' successor, Bonnie-Blanche Schoonover, grew up in Sioux City, Iowa. She earned a bachelor's degree at Morningside College and taught in the first junior high school in that part of the Midwest. She married a fellow teacher, Lynn Schoonover.

Ultimately, she and Lynn came East to continue their educations. While working toward a Ph.D. in English at Radcliffe, she worked in the Radcliffe Library. In 1942, she and Lynn were hired by WPI, he as acting head of the Economics Department and she as librarian.

At the time of Schoonover's retirement in 1964, the library was scattered among six locations and consisted of 54,000 volumes — most of them technical. WPI honored Schoonover as its first librarian emerita.

Albert C. Anderson, the lone male to steward the library, followed Schoonover and was involved in planning the $2.5 million George C. Gordon Library, which was completed in 1968. He retired in 1992, and Helen Shuster, formerly head of technical services, was appointed head librarian in 1993.

"It is no longer possible to contain all the knowledge and knowledge sources needed by the WPI community within the library building," Shuster says. "As director I need to understand the new information technology and how to use it most effectively to meet the needs of the WPI community."

The Record Keepers

In 1896, John K. Marshall was appointed to the new office of registrar. He served until 1910. After Marshall's resignation, the Institute was without the services of a registrar until 1916, when Josephine Frost was appointed. She was followed in 1919 by Gertrude Rogers Rugg.

Born in Brattleboro, Vt., Rugg was raised in Princeton and Grafton, Mass., and received her B.A. from Wellesley College. From 1914 to 1919 she was a part-time secretary to WPI President Ira Hollis and also worked in the Registrar's Office.

She was originally hired to type the voluminous records of committee and faculty meetings, at which each student's progress was discussed. She was a demon at the keys, Mildred Tymeson wrote in *Two Towers,* whose "nimble fingers typed the records almost as fast as her nimble brain could sort them."

Rugg's role extended far beyond her official duties. She edited the school catalog and organized Commencement, among many other tasks. "Gertrude was amazing," says Carol M. (Katie) Curran, secretary to Dean of Undergraduate Studies Emeritus William R. Grogan, who served as registrar in the 1970s. "Her responsibilities seemed endless, but she seemed to thrive on her work.

"She walked with a regal gait," Curran says. "And she was known for her perfect penmanship—a real asset in those days when all permanent student records were handwritten with pen and ink."

When she retired in 1959, Rugg was honored as registrar emerita. In 1959 she was named an honorary member of the Alumni Association. Athena Pappas, who had been Rugg's assistant, became the next registrar. She held the post for about a decade, and was followed by Curran, who served until 1974.

Gertrude Rogers Rugg

Robert Long II then became the second man to hold the title of registrar. Long, associate professor of physics, also served as head of the Physics Department for a time while occupying the registrar's chair. Joseph Mielinski '63 took over for Long in 1985. Then in 1987, Paula Delaney '75 became the first alumna to become registrar.

Since Delaney stepped down in 1992, four more women have served the Institute as registrar, including Jocelyn Kent Smyth, a member of the Class of 1982, and Janet Battaglia, both of whom served in an interim capacity. Kari Blinn became WPI's current registrar last year.

—Bonnie Gelbwasser

Especially in WPI's early years as a coed university, women, distinctly in the minority, felt conspicuous in class and on campus.

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The gender gap was a constant issue for some women, and nonexistent for others. "I never expected to be treated any differently and didn't notice (or pay attention) to any differences," says Elizabeth Hanlon Wood '78, an attorney in Hingham, Mass. "I cannot remember a moment when equality did not prevail," says Sandra Theros '82, a teacher in the Worcester public schools and a PC software trainer.

Lorrie L. Comeford '84, assistant professor of chemistry at Salem (Mass.) State College, says she laughed when asked if she was ever treated differently from male students. "Yes—all the time. Every day," she says. "I knew there was no official intent by the administration to treat women students differently or make them feel unwelcome, yet this was the atmosphere."

The 1970s was a decade of adjustment, as some women reveled in the attention and the surplus of male companionship, while others cringed at the "fishbowl" atmosphere. Many of the early women undergraduates remember being photographed as they walked across campus just because coeds were still such an oddity. Allison J. Huse Nunn '73, now a critical care nurse at Holy Family Hospital in Spokane, Wash., says, "professors called on us a lot. They knew our names and faces in a sea of males."

Incidents recalled in anecdotes from the classroom and laboratory range from off-color jokes (and the even more embarrassing apologies and jokes left unfinished because "There's a lady present!") to condescending comments and even outright harassment. "I was sexually harassed by a chemistry graduate student in my junior year," wrote a 1974 graduate. "Unfortunately, at the time I did not recognize it as such and did not report it. Instead, I took a C because I spent so little time in the lab that semester."

Some women complained that they were not taken seriously ("What do you care?

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Two Voices from 2

Nancy Wood Popinchalk '73

Computer Science Student
University of Hartford, Hartford, Conn.

JANET WOODCOCK

I was inspired to pursue an engineering career by my sister, who is 15 years older than me. She hung around our Dad's automobile repair shop when she was growing up and took mechanical drawing and shop in high school instead of home ec. When she was old enough to drive, she bought an old car, took the engine apart, and put it back together on her own. Mind you, this was in the mid-1950s.

After high school and a brief stint in art school, she got a job in the engineering department at a local company and eventually went into management. She was ahead of her time. She took great pride in doing the unexpected; she loved figuring things out and encouraged me to do the same. I was shy and probably would have become a kindergarten teacher if she hadn't been there to challenge me.

I knew I would pursue some kind of math or science major in college. When I found out that WPI was accepting women, I knew immediately that that was where I wanted to go. The fact that it was almost exclusively male was more of a challenge than a deterrent. I did not apply anywhere else.

During my first year, I was one of 26 women undergrads; we were definitely noticed. We got some grief from other students and some professors, but mostly we were welcomed. I think the administration wanted us to succeed and in many ways supported us more than some of our male classmates.

I had opportunities I might not have had were I not a woman. For example, during my freshman year I was invited to join a team participating in the "Clean Air Car Race" from MIT to Cal Tech. What an experience! I think our team got a little extra attention because I was a woman—I was even invited to appear

on the *Today* show with two other entrants (men) from MIT and Cal Tech.

In those earlier years women had innumerable opportunities to be pioneers. At first most of us felt we had to prove we could make it at WPI the way it was. We didn't focus on how we wanted to change the university to fit our needs, but rather on how we could blend in. WPI was going through other profound changes at the time. I worked on a WPI Plan planning committee that was the beginning of the metamorphosis that led to the university becoming the unique place it is today.

Many things happened during those first few years that seem insignificant now, but were important to those of us who were there. There was the brief period when Maryann Bagdis [now Maryann Bagdis Goebel] served as student body president when the elected president dropped out; and the time six or seven of us were invited to pledge a fraternity; and the time I worked with Dick Olson, math professor and men's crew advisor, to start the women's crew team in the spring of 1972.

Nancy Popinchalk today and with her Clean Air Car Race teammates.

One of the pluses I got from WPI was the confidence that I have something to contribute. The team experiences in my projects were important in enabling me to succeed in predominantly male work environments.

The career/family balancing act has been a big issue for me. I always felt pressure to have a career in engineering—to prove that women can be successful and that my four years at WPI were not wasted. When my first son was born I decided I was not willing to pay the cost of having it all, so I put my career on hold for 10 years. [Nancy and her husband, Paul Popinchalk '71, have two sons, Seth and Samuel.]

The liberation of women in this country has made its greatest strides since the 1960s, when I was a teenager. To truly be liberated is to have choices—to be freely able to choose, for example, between a fast-track career in a male-dominated field or to take time for parenting and feel that it is no less valid. I feel that I am quite liberated; I made the choices that worked for me.

Now I find myself trying to figure out what I want to be when I grow up. Having worked on two nuclear plant construction projects and as an environmental specialist, I recently passed the EIT exam, the first step in going for my Professional Engineer's license. And I'm pursuing a computer science minor at the University of Hartford. In many ways I feel I am starting all over again. But I still feel, after all these years, that I have a lot of choices and options as a direct result of my WPI education.

This fall Seth will enter WPI as a freshman—25 years after I did. I'm told he will be the first student whose parents were both WPI undergrads. To his credit, Seth's choice of college resulted from his own research, not the undue influence of biased parents. The academic excellence of WPI is clear to him.

place. I cancelled an appointment at UPenn and made an appointment, instead, at WPI. I met with Kay Dietrich, director of admissions, for about two hours and drove away knowing I would be back that August.

Now as an alumna, I continue to believe that WPI is a special institution. It is unique in so many ways, from the WPI Plan to the professors to the administrators, coaches and students. But I found some of the most remarkable people to be the WPI women.

NEIL NORUM

Deb Sanna, right, with her sister Jen.

Deb Sanna '93

Electrical Engineer
Knolls Atomic Power Laboratory
Martin Marietta Corporation
Schenectady, N.Y.

It was June 1988. My junior year of high school had ended and I had just begun the biggest trip of my life. I was going "out East" to look at colleges. My father and I left Madison, Wis., with a list of six schools. I was looking for a big, exciting university with a good engineering program, though I did remind myself to keep an open mind (which can sometimes be hard for a 16-year-old).

After looking at several schools in upstate New York, my father and I began a scenic Sunday drive to Boston. We were on Park Avenue in Worcester when I noticed WPI. I looked it up in my college guide; I remember reading about projects and more projects. We weren't in a hurry so we decided to stop and look around.

It was beautiful. I knew this was a special place. I cancelled an appointment at UPenn and made an appointment, instead, at WPI. I met with Kay Dietrich, director of admissions, for about two hours and drove away knowing I would be back that August.

My junior year at WPI was very special. I got to share the WPI experience with my sister, Jen '95. Jen applied to WPI with some apprehension; she did not want to follow in my footsteps and be known as Deb's little sister. But she knew WPI suited her character: enthusiastic, outgoing, hardworking and unique. Some of our best times together were spent at WPI. The WPI environment helped us become more than just sisters—teammates, sorority sisters and best friends.

Like all WPI students, WPI women work extremely hard academically. But WPI women also balance their time with student government, Greek life, SocComm, athletics and other school activities. One of the most memorable experiences I had at WPI was the 1992-93 varsity swim season, when my sister and I and 19 other women did what no other women's swim team had done—achieve a winning season (9-6). These women exhibited enthusiasm, energy and a drive for excellence. But that attitude is not specific to the women's swim team; it is the norm for the women at WPI.

"Ma Riley" Remembers

Ma Riley stands between Gwynne Peterson '73 and John Kaletski '72, who are now married.

Elaine S. Kowalewski '71 (M.S.) didn't expect to become a mother so early in life, but in 1969, when she accepted the post as dormitory counselor for the first women to move into Sanford Riley Hall, "Ma Riley" she became.

"I was responsible for keeping order on the floor," Kowalewski says. "Not in the role of police officer, but to be available with help and information about anything I could and to assist with the organization of dormitory functions and parties. I tried to keep my door open. I was really very fond of the women. Even though I was four years older, we all had a common bond."

Kowalewski, who is currently pursuing a doctorate in mathematics education at Teachers College, Columbia University, said she came to WPI on the recommendation of her advisor at Merrimac College, where she earned her undergraduate degree. One of the few women to enroll at the Institute as graduate students in those years, she was approached by the administration and asked if she would be willing to take the dorm counselor job. "I just couldn't pass it up," she says.

Having women and men living on the same floor of Sanford Riley presented few problems, Kowalewski told a reporter for the (Worcester) *Evening Gazette* in 1969, though the men did try some tricks for getting beyond the locked doors that separated the male and female residence areas—such as taking the pins out of the hinges.

For Kowalewski and the other women a more important challenge was adjusting to being a decided minority on campus, she says. "Perhaps we were all accustomed to being in the minority, in some sense. If we came from coeducational schools or colleges, there were probably more men than women excelling in mathematics and the sciences and looking toward careers in these disciplines.

"I think one reason all of us may have shared for choosing WPI was a desire to do what hadn't been done before. Perhaps we wanted to grasp the opportunity to receive an education in the sciences from an institution with an excellent reputation—one that had previously been closed to women."

—Bonnie Gelbwasser

(Continued from page 16)

You're only here for your 'M.R.S.'," was a common taunt), or were held to lower expectations than their male counterparts. Others said they felt the need to prove themselves. But in spite of some negative incidents, most women say they had equal opportunities academically, found support from many male faculty members and administrators, and found role models among the growing number of women who were joining the faculty and administration.

Of the people women graduates recall as especially helpful, one name comes up repeatedly: John van Alstyne, retired professor of mathematics and dean of academic advising. He's remembered as a supportive father figure to many WPI women. "Dean van A kept me in school. When I ran into financial trouble, he went out of his way to find a solution so that I could stay at WPI," says Leslie A. Knepp Azaret '80, an engineering supervisor for AT&T Bell Labs. "Professor van A helped me put myself together and gave me the confidence to succeed and go after everything I wanted," says another alumna.

"We hated those girls from Becker!"

—Eleanor M. (Cromwick) Kelly '81, Superintendent, Turner Construction Co., Washington, D.C.

If blending in academically was sometimes difficult, fitting in socially was even harder on a campus where males were used to traveling to mixers at Becker Junior College and local nursing programs. WPI women had to transcend stereotypes of being "eggheads" and "walking computers." While dancing at a fraternity party, a female student was asked by her partner if she was from Becker. When she told him she went to WPI, "he did a 180 and I never saw him the rest of the night!"

Relations between the sexes eased up as more women enrolled and men saw that these "co-techs" were people, too. Dating progressed to marriage proposals, and today the Institute has many alumna-alumnus couples. Lee Small and classmate John Zorabedian Jr. were the first. Michelle A. Riel Lord '74 received a proposal on Earle Bridge. Now a librarian in Southington, Conn., she and her former classmate John Lord will celebrate their 20th anniversary this year.

Quickly, the women infiltrated previously all-male institutions: the dormitories, the student newspaper—even the fraternities. Nora Blum '73 became the first female editor

of *Tech News* in 1969. Three women from that same class—Joyce (Caplovich) Wilson, Diane Gramer Drew and Janet Merrill Mambrino—joined 29 men in pledging to Alpha Epsilon Pi fraternity in 1969, though they were unable to join the national fraternity.

WPI women moved into positions of leadership in activities and student government—a great source of pride for their peers. And they founded their own extracurricular activities to express their interests and foster companionship. These included the first sorority, Phi Sigma Sigma, established in 1977. Two others, Alpha Gamma Delta and Delta Phi Epsilon, followed. (Delta Phi Epsilon was recently closed by the sorority's International Executive Council.)

Cynthia L. Bruder '81, now owner and president of Factor Designs Inc. in Topsfield, Mass., and Betsy Steigerwald Yingling '80, a planning engineer with Northeast Ohio Regional Sewer District in Cleveland, were among those who helped start a women's singing group, the Women's Chorale. Yingling remembers, "In my sophomore year, we were bused over to Anna Maria College to sing in their choir, directed by Malama Robbins. She loved us and we thought she was wonderful. We convinced WPI to hire her and start a real women's singing group. And so, in my junior year, the Women's Chorale was born, and has since flourished."

Above, early members of WPI's first sorority, Phi Sigma Sigma. Below, Malama Robbins, seated, at right, with members of the Women's Chorale.

Longing for the opportunity to participate in competitive sports, women students, led by Patricia Graham Flaherty '75, created a women's varsity sports program (see *WPI Journal*, Summer 1990). And in 1975, a chapter of the Society of Women Engineers was chartered. Mary Hardell, associate professor of computer science, was the group's first advisor. She is now co-advisor with Holly Keyes Ault '74, assistant professor of mechanical engineering.

The year of our graduation, someone decided women would wear pink graduation gowns. There was a huge protest, and the decision was rescinded. It was too late, however, for those of us who picked up our gowns early. Several spectators at the graduation ceremony inquired if the pink gowns signified high distinction. Isn't it odd that they didn't wonder why no men were graduating with this distinction?—The few, the proud, the PINK!"

—LindaLeigh (Richert) Aberdale '88,
Senior Software Engineer,
Digital Equipment Corp., Palo Alto, Calif.

Social changes, and the paths blazed by women before them, may make life even easier for the female students of the 1990s. After more than two decades, women are now part of the norm at WPI. Perhaps just as significant, notes Francis C. Lutz, dean of undergraduate studies, time has shown that women are as capable as men of succeeding—and excelling—in the Institute's demanding academic climate.

"The women in the first coed classes tended to be the academic superstars—the cream of the crop from their high school classes," he says. "But one day I noticed that the female students in my classes had become average—no better or worse than their male counterparts in terms of performance on examinations. That was a good day for WPI, because it meant we had advanced significantly in our ability to attract women to campus, and that women can be the equivalent, academically, of men and succeed."

But while women have demonstrated their parity with men in academic performance, they are a long way from parity in sheer numbers. Though they now make up about 20 percent of the undergraduate student body, they are still outnumbered.

"I remember registering at orientation, looking around at the line of students, and asking my parents where all of the women were," says Danielle N. LaMarre '89, now an environmental engineer with Camp, Dresser & McKee in Cambridge, Mass. "But that was the only time I was ever scared that I would not be able to handle being in the minority."

Sherri L. Curria '93, who works as a member of the Technical Assistance Team for the U.S. Environmental Protection Agency in Burlington, Mass., remembers a different initial reaction to the lopsided male-female ratio. "I looked at my freshman orientation group and saw I was the only woman among 20 or more men. My reaction then (I was 18 and boy-crazy) was, 'Wow! All right!'" But her elation wore off as she faced the difficulty of finding compatible female friends among a small number of peers.

"I think that's why I embraced the sorority rush with such eagerness," she says. "I remember walking in and saying, 'Wow—80 women in one room!'" Tennis and student government offered other opportunities for Curria to receive guidance and support from

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other women students, who she says "went out of their way to help me with anything from calculus homework to informing me of which fraternity had the best-looking men."

Many alumnae say being outnumbered at WPI proved to be excellent preparation for the "real world," as graduates found themselves facing similar situations in their professional lives. "When I first started at WPI the male-female ratio was a culture shock," says Marie J. Harriman '86, a mechanical engineer for Pitney Bowes in Stamford, Conn. "During my four years at the Institute I got used to it. Now, working in a male-dominated field, I'm glad I got through the acclimatization process. It made my first job that much easier, compared with my female colleagues in engineering."

"Coping with men at WPI will prepare you for coping with men in the workplace and elsewhere," says Jennifer L. Mellone '86, a systems engineer with ESL Inc. in Sunnyvale, Calif., who notes that her avocations—scuba diving and flying (including flying search and rescue missions for the Civil Air Patrol)—also tend to attract more men than women. As part of her job, Jayne Rossetti once went to sea for two weeks on an aircraft carrier to test a new landing system. "People asked me if I was nervous being on a ship with all those sailors. But after being one of two women in a class with 1,800 guys, I was prepared for anything."

Says Teresa B. Tucchio '88, an engineer with the Electric Boat Division of General Dynamics, "I was sitting at a meeting at work the other day and I realized that I was one of three female engineers out of about 50 there. That didn't intimidate me; it just caused me to reflect."

"In my profession, the majority of students are now female," notes veterinarian Gail A. D'Amico Mason '79, who, with her husband, purchased Bath-Brunswick Veterinary Associates in Brunswick, Maine, in 1989. "In the business/engineering climate, however, males predominate. But 'predominate' doesn't mean 'dominate.' I think any women scientist or engineer graduating from WPI is fully prepared to function in an aggressive, fast-paced technological society with women or men."

The ability to work confidently and competently in their sometimes male-dominated professions is just one of the qualities WPI's alumnae gain in their years on campus, notes Jeannine M. Machon '85, a consultant with Anderson Consulting in Hartford, Conn.

"WPI women are special," she says. "I came to WPI, not because it was a male-dominated university, but because it was a top-five engineering school. One of the things I've noticed about myself and about other WPI women is our ability to work through a problem and to get along and work with all other team members. WPI women are always team players—willing to roll up their sleeves, solve problems, discuss issues, and not stand apart from men on their teams.

"The contribution that WPI has made to my being is the added strength I gained in being a woman at WPI, being treated as an equal, and not having to get caught up in any sexuality games. That inner strength has carried me this far in my career, and hopefully will continue to carry me up the ladder of success."

"WPI gave me the tools I needed to solve problems, work in teams, and provide the leadership I needed in many of my jobs," says Denise C. Gorski '75, an engineering manager for IBM Corp. in Poughkeepsie, N.Y. "My leadership strengths developed through all types of opportunities we had, being one of the first classes with women on campus. I had the opportunity to be the first woman student body president, which gave me the experience of dealing with controversy and solving problems for a large group of diverse people.

"In my current job assignments I find myself dealing with these types of situations often and I have this experience to fall back on. WPI also prepared me for one of the toughest assignments I have had so far in my career—being a female manager managing only men."

"We certainly want more women; I don't make a secret of that. But first we have to have a real switch in women's patterns—a shift in opening up their eyes to the opportunities that do exist for them in engineering and science."

—Kay R. Dietrich,
WPI's Director of Admissions

Although there are no stated goals with regard to the male-female ratio at WPI, the Admissions Office has seen a steady increase in the number of women applying to and enrolling at the Institute. Still, Dietrich says, the numbers have reached something of a steady state, and only minor changes are possible until societal barriers to feminine interest in engineering and other nontraditional fields are addressed.

While some of the activities coordinated by the Admissions Office are designed specifically to reach and enroll women, there is a lot of overlap with the overall marketing effort, Dietrich says. For example, sorority members make phone calls to female applicants who express an interest in sororities, just as members of fraternities and other campus groups do.

Another successful recruitment strategy

Above, Judith Nitsch. Opposite, Leslie Knepp Azaret and former dean John van Alstyne. Azaret says van Alstyne helped her through financial troubles.

has been a woman-to-woman "pen pal" program, in which current students write to prospective students stressing elements of the WPI experience—both academic and social—that have been found to appeal to women, for example, the teamwork common to WPI's required projects, and the exploration of the social impacts of science and technology that students undertake in the Interactive Qualifying Project.

Once women students are accepted for admission, they receive several more letters; one comes from Judith Nitsch '75, who, after a successful career working as a partner in a major civil engineering firm, founded her own company, Judith Nitsch Engineering Inc. A recipient of WPI's John Boynton Young Alumni Award for distinguished service to WPI, Nitsch is now a member of the WPI Board of Trustees.

The Admissions Office is also planning new initiatives, such as an overnight program in conjunction with the Society of Women Engineers. High school women will be invited to spend a day on campus attending classes and activities, followed by a night's stay in a residence hall.

One of the most effective recruitment tools WPI may have, though, is the impressive record of achievement—on campus and after graduation—of the women who have defied the odds and joined fully in the academic and social life of WPI, participating as equals in activities, sports and academics, and earning their B.S., M.S. and Ph.D. degrees at this once all-male institution.

Words of Advice.....

The University Relations and Alumni offices asked women graduates what advice they would offer current female students about coping with life at WPI and in the workplace. Here are some of their answers:

"Remember, you are equal, not superior or inferior. Don't allow anyone to treat you different from male co-workers or fellow students. Also, don't expect any concessions—or demand any—just because you are female."

Allison J. Huse Nunn '73
Critical Care Nurse,
Holy Family Hospital,
Spokane, Wash.

"Don't expect to be treated differently. Do your work consistently and conscientiously and you will be appreciated and respected for it."

Elizabeth Hanlon Wood '78
Attorney, Hingham, Mass.

"Keep your options open, and realize that you don't have to do everything at once. I worked for eight years and have been home (very happily) with my children for seven years. I am now in the process of getting an M.B.A. and doing some consulting. I feel that by keeping my options open and being flexible I have been able to accomplish my goals."

Beth Driscoll Kinney '79
Homemaker, Summit, N.J.

"Work to form your own network of mentors and friends, and serve in the same capacity to new women engineers."

Denise Johnston-Hafenbrack '85
Manufacturing Engineer,
Blount Oregon Cutting Systems,
Portland, Ore.

"Be a strong female. Always ask questions. Demand to be doing the same work and to have the same responsibilities as your peers—whether they are male or female. If you don't like your work or your work environment, don't be afraid to change jobs."

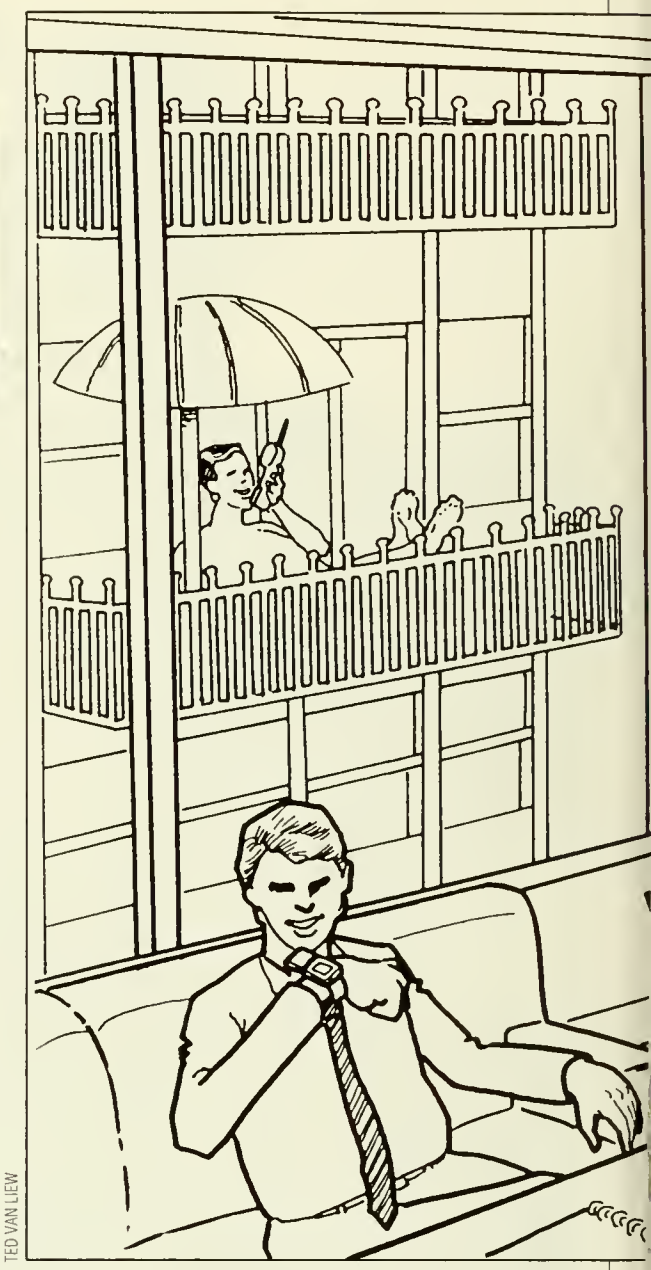
Danielle N. LaMarre '89
Environmental Engineer,
Camp Dresser & McKee Inc.,
Cambridge, Mass.

"Self-confidence is the key in male-dominated surroundings. If you believe in your abilities and strengths, others will too."

Theresa A. Schmidt '92
Technical Coordinator,
GE Research and Development,
Schenectady, N.Y.

Unplugged

By Michael Dorsey



TED VAN LIEW

Increasingly, voice and data transmissions are taking to the airwaves as researchers and telecommunications companies bring about a bold era of wireless information networks.

With its pioneering work in the field, WPI's Center for Wireless Information Network Studies is playing a major role in creating a new wireless world.

It's 7 a.m. You board a New Haven Railroad train for the commute to your office in the Big Apple. As you glance at the headlines in *The Wall Street Journal,* you remember something you need to discuss with a co-worker before an 8:15 meeting. You reach into your jacket pocket for your personal communicator and tap in her phone number, catching her in the middle of a traffic jam on the Long Island Expressway.

Completing the call, you decide you need a new graph for your presentation at the meeting. You open your briefcase and retrieve your personal digital assistant (PDA)—a battery-powered device about the size of a paperback book—and send a brief e-mail message over the airwaves to your assistant, asking him to go to work on the graph as soon as he gets in.

Turning again to the *Journal,* you read about a new company in Switzerland that might compete with your firm in the European market. With your PDA, you send a wireless fax to your Bern office, taking advantage of a global communications service that bounces your message off a satellite. In a few minutes, your small digital friend beeps to tell you a report from your Swiss colleagues has arrived.

As the report scrolls across the screen, you decide you'd better bone up on the financial performance of your European subsidiary. With a few keystrokes, you link your tiny computer—wirelessly—to the local area network in your office, log on to the computer sitting on your desk, and call up a spreadsheet with the numbers you need.

As the New York skyline looms in the distance, you remember a lunch date you've scheduled for today. With your PDA, you tap into the Internet to read some observations from other computer users about a new Indian restaurant near your office. It sounds good, so you grab your personal communicator again and make a reservation with the restaurant's voice-mail system.

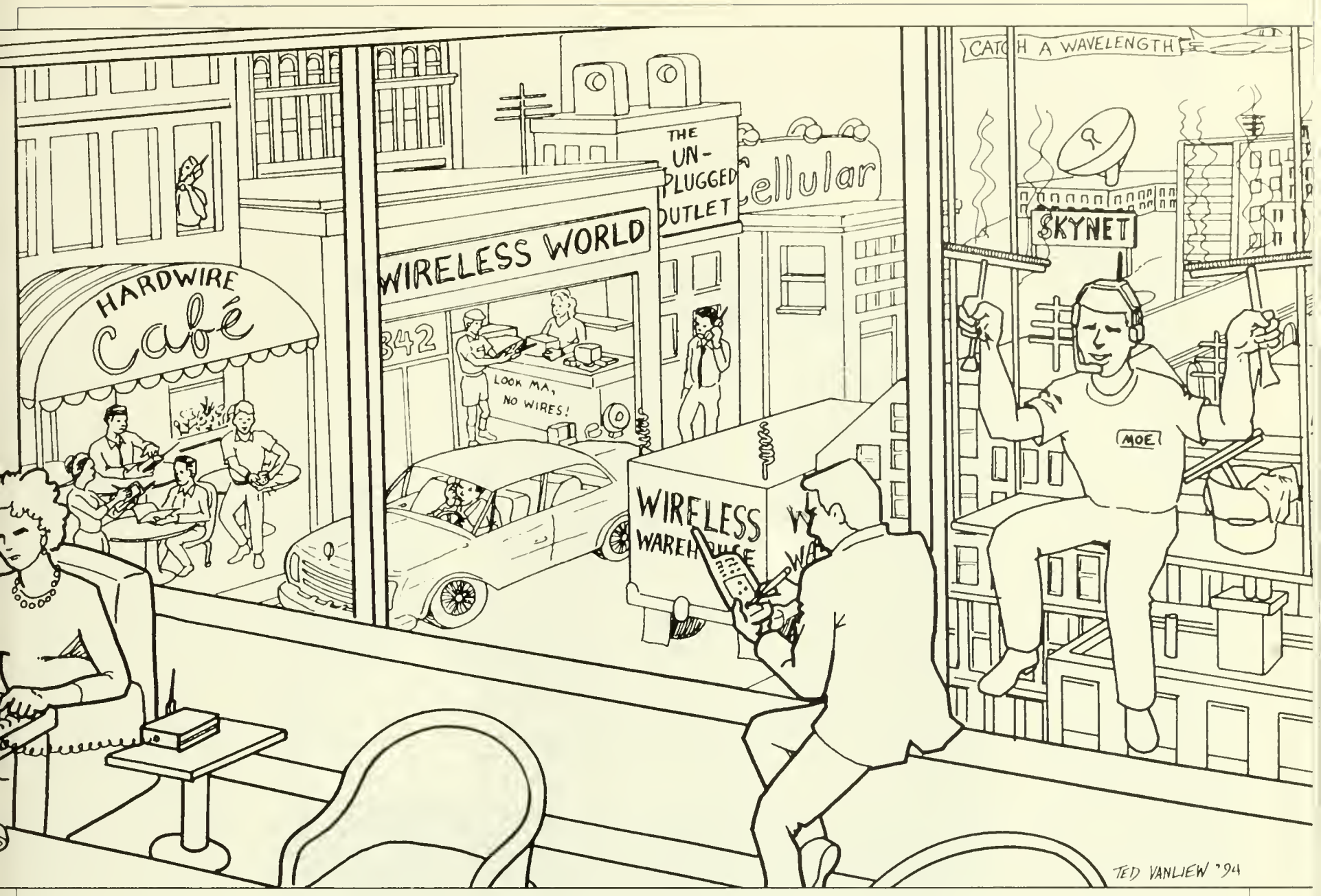
As the train pulls into Grand Central, your communicator beeps to alert you to an incoming call. It turns out to be an aluminum siding salesman—one of the disadvantages, you think as you rush for a cab, of having your phone number travel with you everywhere you go.

That scenario, communications experts say, may be realized by the end of the 1990s—perhaps sooner. With the dawn sometime this decade of what has been dubbed personal communications service, or PCS, the wireless communications industry hopes to unplug our telephones and computers, letting us stay in touch with other people and other computers no matter where on Earth we roam.

Already, communications systems that use radio waves instead of wires are making tremendous inroads into the business and consumer markets. Cordless telephones, for example, are becoming commonplace in American homes. Some 17 million were sold in the U.S. in 1992 alone—topping sales of traditional wired phones.

Introduced just a decade ago, cellular telephones are now becoming ubiquitous. There are more than 12 million cellular phones in the U.S. today and another 20 million worldwide, a number that may well quintuple over the next decade. In some areas of the world, including Eastern Europe and Asia, engineers are turning to cellular systems to rapidly expand telephone networks without the expense of running wires across remote countryside or replacing antiquated telephone equipment.

The technology needed to transmit data with radio waves has also been evolving rapidly. Wireless local area networks are showing up in offices with increasing fre-



quency and mobile data networks—which let users send short bursts of information to distant locations—are becoming more widely available all the time. All of this adds up to a $100 billion industry that serves some 60 million people in the U.S. alone.

"The whole communications industry is in the process of migrating from wires and wired networks and services to wireless communications," says Allen Levesque '59, senior scientist in the Wireless and Secure Systems Laboratory within GTE Laboratories (see story, page 27). "As people, particularly in the business world, come to recognize the convenience and efficiency you gain by accessing wireless networks, the industry will grow very, very rapidly."

The rapid progress of the wireless industry has depended on basic research aimed at overcoming the significant challenges involved in transmitting information with radio waves. Over the past nine years, WPI has become a leading center for research on wireless information systems.

Under the direction of Kaveh Pahlavan, Weston Hadden Professor of Electrical and Computer Engineering, the Center for Wireless Information Network Studies (CWINS) has developed an international reputation for its fundamental research on the characterization of indoor radio propagation, analysis of high-speed data communication alternatives, and studies of various wireless access methods.

The world of wireless data communication is really two worlds. One, the realm of mobile data services, lets users send data over wide areas. The second, the province of wireless local area networks, lets computers communicate over the airwaves with other computers and backbone networks inside buildings.

Mobile data systems are the offspring of the highly successful paging industry and employ the same high-power, low-speed radio transmissions used by pocket pagers. The field is dominated by two companies: Ardis, a joint venture of IBM and Motorola, and RAM Mobile Data, created by RAM Broadcasting and BellSouth. Both let businesses stay in touch with field technicians and do credit card verifications, among other applications; mobile data networks are also used by portable computer users for sending electronic mail.

Mobile data systems are expected to grow significantly in the years ahead. They currently generate $260 million in revenue and serve 380,000 customers, but that could jump to $2 billion and 3.4 million people in just four years, *The Wall Street Journal* reported recently. What may make that growth possible is the introduction—already under way—of mobile data systems that use cellular telephones.

While it is now possible to transmit data with a cellular phone, slow transmission speeds and less-than-perfect signal quality make it impractical. The introduction of digital cellular systems—the trend in the cellular industry—may eliminate these problems, lowering the cost of using mobile data services and making them available to more users in the U.S.

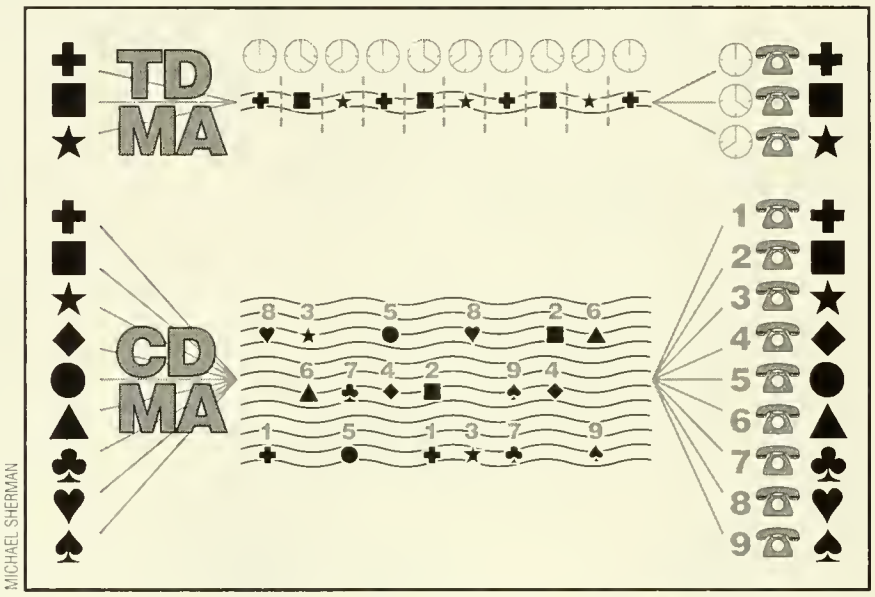
By going digital, cellular systems will also reduce the congestion that began to affect cellular service in some metropolitan areas in the mid-1980s as more and more users competed for the same frequencies. Information transmitted digitally can be compressed, increasing the capacity of a system several times. In addition, several schemes have been developed that will let more users share the frequencies allocated to mobile radio services.

"There are two basic resources for wire-

less communications: frequency and time," Pahlavan says. "And there are three ways of using those resources in a cellular system." The first is called frequency division multiple access, in which each caller is assigned a separate frequency. This is how the existing cellular system works.

Time division multiple access (TDMA) places multiple users on the same frequency by breaking each signal into small packets and sending them out at precise intervals. Phones at the other end look for packets arriving at the proper intervals and put them back together to recreate the original calls (see illustration).

"With code division multiple access, or CDMA, a technique developed by the military, you take advantage of both frequency and time," Pahlavan says. "Callers use all of the frequencies all of the time, unlike FDMA, and can broadcast continuously, unlike TDMA."



Bottom, Pahlavan at the 1992 PIMRC conference in Boston. Top, two modes for digital cellular systems: TDMA (time division multiple access) and CDMA (code division multiple access). See the article for an explanation.

To distinguish callers from one another, each is given a unique computer-generated code or signature. The receiving phones search out signals that have the proper code. Because it diffuses every signal over the entire range of available frequencies, this technique is also called spread spectrum.

The standards developed for the next generation of digital cellular service using TDMA can increase the capacity of a cellular system by up to six times, Pahlavan says, while CDMA claims a more than tenfold increase in capacity. "With CDMA, however, you are talking about soft capacity," he notes. "Because everyone uses the frequencies at the same time, as you add more and more users the quality will deteriorate."

Beyond digital cellular technology lie communications networks—still on the drawing boards—that will zap voice, data and fax transmissions to virtually any spot on the globe using satellites. One system already announced, the $3.4 billion Iridium, will be built by Motorola in cooperation with a number of international partners. William Gates, chairman of Microsoft, and Craig McCaw, head of the cellular telephone giant McCaw Cellular Communications Inc., recently announced plans to raise $9 billion to build an even larger system called Teledesic.

Also under development is PCS. In essence, personal communications service will be an extension of cordless telephone technology that will enable callers to use their portable phones just about anywhere they go—not just within their own homes. Still in development, the structure of PCS will be similar to that of cellular systems.

Cellular networks are divided into large geographic units called cells. Cellular phones transmit to large antennae in the middle of each cell that are, in turn, connected to each other by conventional phone cables. As a user travels along, his call is handed off from cell to cell, allowing the call to continue uninterrupted.

PCS networks will be broken up into much smaller cells—dubbed microcells—served by small antennae located on the tops of buildings or telephone poles. Because they won't have to broadcast very far, PCS devices will require much less power than cellular phones. That means they can be much smaller, lighter and less expensive. "In its most advanced form, a PCS unit will resemble Captain Kirk's communicator from *Star Trek*," Pahlavan says. "You'll just open it up wherever you are and start communicating."

The FCC is expected to auction off a generous portion of the ultrahigh frequency section of the electromagnetic spectrum for use by PCS. There should be enough bandwidth to enable these pocket-size devices to send everything from text to video to multimedia files, enabling users to contact other human beings, send electronic mail, or tap into global computer networks and computer databases.

PCS-like services are also envisioned in Europe and Japan, where the second generation of cordless telephone service is already in operation.

While the promise of all PCS systems is great, the reality is still taking shape, Pahlavan says. "PCS is like the unicorn. You can define it, but you can't see it. There are still many obstacles to overcome before it comes about." These include the challenge of getting the many companies interested in investing in PCS and the many nations that want to build PCS networks to agree on standards, a problem that already plagues the development of competing digital cellular systems, he notes.

"Part of the problem with setting standards," Levesque says, "is that the technology moves so fast and the standard setting process is comparatively slow. It takes several years to make a commitment to a standard, and in the meantime several other competing standards may come along. That is why the standard-setting bodies in the U.S. have decided, in effect, to let the market forces prevail with digital cellular."

Just as the mobile data industry seems primed for explosive growth, the companies that make wireless local area networks (LANs) are forecasting a bright future for their technology. According to Pahlavan, wireless LANs have several important advantages over conventional wired networks.

First, he says, they are much easier—and less expensive—to install. Running wires through walls can be difficult and costly, unless they are put in when a building is constructed or remodeled. And once the wiring is in place, rearranging and relocating offices can become an expensive undertaking.

Then there are trade shows, temporary offices like political campaign headquarters, large, open work spaces like factory floors, buildings made largely of marble or stone, and historic buildings. Wireless networks are often the preferred way to link computers together in such places, since running wires doesn't make sense, is too costly, or simply isn't allowed.

While they have advantages, wireless LANs also have an important shortcoming, Pahlavan says. Wired LANs that transmit at 10 million bytes (10 megabytes) per second are now common and 100-megabyte systems are on the market. The next generation will operate at 650 megabytes per second, a speed that will make it possible to send interactive TV and multimedia files.

While they are gaining speed all the time, wireless LANs that use radio (some systems transmit data optically) are pokey by comparison. The most advanced systems have reached the 10-megabyte-per-second mark, but most wireless LANs on the market are considerably slower. Significant research is going on to speed up wireless LANs and incorporate them into more demanding environments, Pahlavan says.

The speed limitation, and the reluctance of companies that had already invested heavily in wired LANs to switch gears, made the growth of the wireless LAN industry slow for much of the 1980s. But the growing popularity of battery-powered portable computers—everything from laptops to personal digital assistants like Apple Computer's Newton—has changed all that. Now that people can work on their computers far from the nearest plug, they want the same freedom when they tie into a computer network. Adding a wireless system to an existing LAN can make that possible.

Also contributing to the renewal of interest in wireless LANs are technological strides that have lowered the cost of wireless modems and shrunk them from bulky boxes that required a lot of power to credit card-sized devices that plug into a portable computer. As a result, *PC World* recently noted, the number of wireless nodes installed in the U.S. jumped from just 8,000 in 1989 to nearly 30,000 in 1992. It should hit the million mark in two years.

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Pahlavan, right, and Ph.D. candidate Ganning Yang in WPI's Center for Wireless Information Network Studies.

When Kaveh Pahlavan arrived at WPI in 1985, the field of wireless data communications was still in its infancy. Soon after joining the electrical engineering faculty, Pahlavan, who began working on wireless indoor radio communications as a consultant to GTE Laboratories in Waltham, Mass., in the early 1980s, founded the Wireless Information Network Group. Six years later, the group evolved into the Center for Wireless Information Network Studies.

"This was the very first university research program on wireless indoor data networks in the U.S.," Pahlavan says. "Within a year or two, Rutgers and Virginia Polytechnic universities founded similar centers. For many years, these three were known as the major programs in the United States. Now many people in the telecommunications industry identify WPI with wireless activities. We started at just the right time."

Over the past eight years the center has produced six Ph.D.s specializing in wireless communications—more than any other university, Pahlavan says—and center researchers have published more than 100 papers and conference proceedings. Pahlavan is editor-in-chief of the *International Journal of Wireless Information Networks,* which published its inaugural issue in January, and is currently co-authoring with Allen Levesque a book that will provide a comprehensive overview of the field of wireless information networks.

Pahlavan has also been active in establishing and organizing international meetings of researchers who specialize in wireless communications. In 1990, he was one of the founders of the IEEE (Institute of Electrical and Electronics Engineers) International Symposium on Spread Spectrum Techniques and Applications. In 1991, he was founder, organizer and program chairman of the IEEE Workshop on Wireless Local Area Networks, which attracted to the WPI campus more than 200 scientists, engineers and managers from 10 nations and all of the major manufacturers of wireless technology.

That same year, Pahlavan was one of the founders of the IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), the first international conference on wireless communications. The meeting was held at Kings College in London, where Pahlavan delivered the sole tutorial. Since then it has been held again in London (1991), Boston (1992) and Yokohama (1993). This year it will move to the Netherlands.

The work of CWINS has garnered the financial support of many of the key players in the rapidly expanding wireless communications industry, along with the National Science Foundation. Major supporters include NYNEX Corp., Comdisco Software, Digital Equipment Corp., Apple Computer, Motorola Inc., GTE and Raytheon.

A major thrust of the research conducted by the faculty and graduate students of CWINS is how radio waves propagate, particularly through wireless LANs. In a wired network, signals can go in only one direction—down the cable—so one can assume that when a message is sent from one computer to another on the same network, it will get there and be understood when it arrives.

But things are more complex with wireless systems. Radio waves leaving an antenna travel in many directions at once. In an office, those signals tend to bounce off the

walls, the floor and the ceiling—not to mention file cabinets and furniture. That means each bit of data will arrive at the receiving computer from many directions and with many different time delays, something communications engineers call multipath distortion. The same phenomenon causes ghosting on TV screens in weak reception areas.

For the computer, multipath distortion is like being a confused caller to a radio talk show who forgets to turn down the volume on his radio. He hears his own voice first through the telephone and then a few seconds later through the radio. The confusion caused by data arriving from many directions becomes more severe as the rate of transmission increases, which is why data rates for wireless LANs tend to be considerably slower than those for wired LANs. In addition, the garbling of data tends to increase as the distance between two computers increases, limiting the area that can be covered by a wireless system.

To learn more about the problems of multipath distortion and how to solve them, CWINS has developed numerical models of radio propagation. "The core of any work in this area is a good radio propagation model," Pahlavan says. "If you don't have a good model, you are in trouble. Most of our work to date has focused on radio propagation. This is what we have become famous for."

The models CWINS has developed are based, in large part, on radio propagation data gathered in numerous controlled experiments in the center's laboratory in Atwater Kent Labs, as well as data collected in the field. For example, Pahlavan says, data have been recorded in offices and manufacturing facilities operated by General Motors, Norton Co. and Infinite Inc. Some of this work was funded by a major grant from the National Science Foundation.

In a 1993 study sponsored by NYNEX Inc., Jin-Fa Lee, assistant professor of electrical and computer engineering and one of several faculty members in the Electrical and Computer Engineering and Computer Science departments affiliated with CWINS, conducted a study of radio wave propagation in and around office buildings in New York City. "NYNEX's primary interest was in modeling radio propagation in the streets of New York," Pahlavan says. "We provided them with the measurements and created a computer model of three city blocks."

CWINS researchers have also worked on ways to combat multipath distortion to overcome the data rate limitation. These include the use of spread spectrum and adaptive equalization, a technique in which a radio receiver monitors the characteristics of signals arriving from various directions and attempts to compensate for the frequency shifts and time delays.

Another promising technology is the sectored antenna, which receives radio signals from many narrow "slices" of space around the receiver. The idea is to isolate each possible path signals might take and "hear" each signal separately. The signals from the various paths are then added together to create a stronger, more reliable signal.

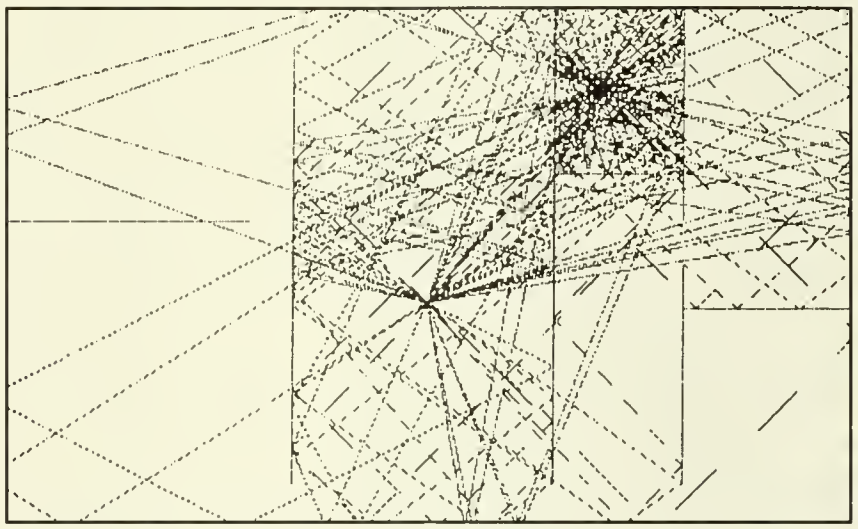
In addition to these basic studies, the center is also at work on software tools that designers of wireless systems can use to evaluate a system before they build it. "Implementing a wireless system can be very expensive," Pahlavan says, "so you want to be able to simulate the system first to see how well it will work."

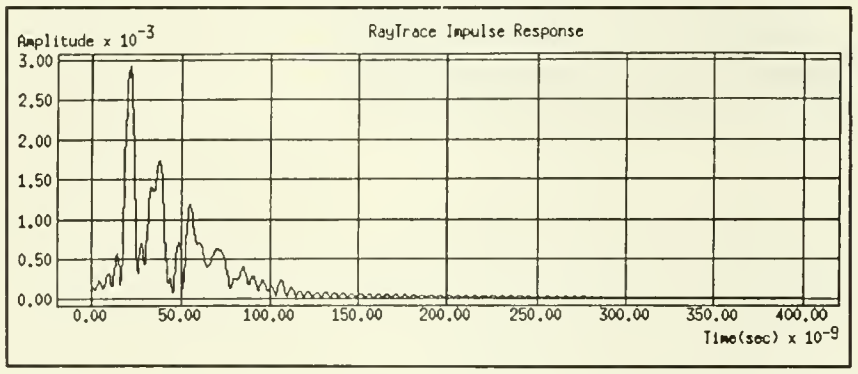
One type of simulation software creates a multipath profile of a wireless setup by using a technique called ray tracing to plot out the various paths radio signals might take as they travel from transmitter to receiver. Another useful tool for wireless systems is based on block-oriented software, which lets an engineer create a system on a computer much as a child builds structures out of Tinkertoys, Pahlavan says.

"The various components of a communications system are represented on the screen as blocks," he says. "You can design a system or add to an existing system by pulling together the proper blocks. The software then analyzes the performance of the system. This is the trend in tool development—making it as simple as possible to create and test systems."

With significant work already completed on modeling and software tools, Pahlavan says he would like the center to turn next to the development, evaluation and installation of actual wireless information networks for specific applications, such as wireless classrooms and campuses. But he notes that a never-ending challenge for the center will be to keep up with the constantly changing nature of the field of wireless communications.

"Doing research in this area is like running on hot sand," he says. "You can never put your foot down for long. You have to keep jumping to new things all the time."





JANET WOODCOCK

Above, from left, graduate students Andrew Parker, Jimmy Wang and Mohammadali Ghazanfari study radio propagation in the lab. The top diagram uses a technique called ray tracing to show the many paths radio signals can take from a transmitter to a receiver inside an office. The highest peak on the graph represents signals arriving through a direct path. The remaining peaks are signals that have bounced off walls and objects. The time delays cause what is known as multipath distortion.

Al Levesque Is Helping Shape a World Without Wires

For most of his more than 30-year career at GTE Corp., Allen H. Levesque '59 has been deeply involved with research aimed at improving the accuracy and efficiency with which data is transmitted from one location to another without the aid of wires. Today, with wireless data networks poised to become one of the most important technologies of the early 21st century, Levesque is helping guide his company—and the world—into this bold new era of communications.

Levesque, now senior scientist reporting to the director of the Wireless and Secure Systems Laboratory within GTE Laboratories in Waltham, Mass., began his career at what was then the Sylvania Applied Research Laboratory after earning a master's degree in electrical engineering at Yale University in 1960.

After doing part-time graduate work at Harvard and MIT, he returned to Yale in 1962 to earn a Ph.D. in electrical engineering, and then returned to the Sylvania Lab. When GTE, which had purchased Sylvania in 1959, moved its laboratories from Bayside, N.Y., to Waltham in 1969, Levesque and many of the other Sylvania researchers were invited to join the GTE operation.

MICHAEL DORSEY

He remained with GTE Labs until 1974, when he joined GTE Government Systems Corporation, located just a few blocks away, where he managed a wide variety of projects in digital communications and was named to head a research and development group within the business unit. In 1988, when GTE formed the Electronic Defense Communications Division within GTE Government Systems, Levesque was named senior scientist reporting to the general manager.

Much of the work he has done over the years has been in the area of advanced digital radio communications. For several years he was involved with research aimed at developing reliable radio systems for communicating with the U.S. Navy's submarine fleet. He also managed a research and development group that developed advanced high-speed modems for transmitting data over high-frequency military communication bands.

"My own individual work in this area included a lot of research on what is called error-control coding," Levesque says. "This is basically sets of techniques for encoding data so it can withstand the vagaries of radio communications media." Levesque is co-author of *Error Control Techniques for Digital Communication,* published in 1985 by Wiley-Interscience. He is also the author of a number of papers on digital communication and once served as associate editor for *IEEE Transactions on Communications.*

While he did not know it at the time, the work he and other scientists were doing to improve data communications for the military was setting the stage for today's revolution in wireless communications. "A lot of the technology being employed in these new wireless communications systems originated in the military communications environment," he says. "So many of the techniques I am dealing with today I've actually been working with for a number of years."

In recent years, Levesque says, his work has turned more and more to issues facing the commercial wireless communications industry, including the challenges of overlaying wireless data services onto existing wired and wireless voice networks. "I've dealt with a number of these issues, as well as with the problems of translating different communications protocols when you connect wired and wireless systems," he explains.

With its acquisition in 1990 of Contel Corp., GTE became the second largest provider of cellular telephone service in the U.S. The Wireless and Secure Systems Laboratory was created at that time to become the focal point for the company's efforts to continue to be a major player in the evolving world of wireless communications.

In April, Levesque joined the new lab, where he will coordinate the work under way there in the area of data communications. "I will also serve as a technical liaison across projects and across departments at GTE Labs," he says. "And I will be the primary technical interface with the rest of the company—including the operating divisions that will actually provide these services—in the area of wireless data communications."

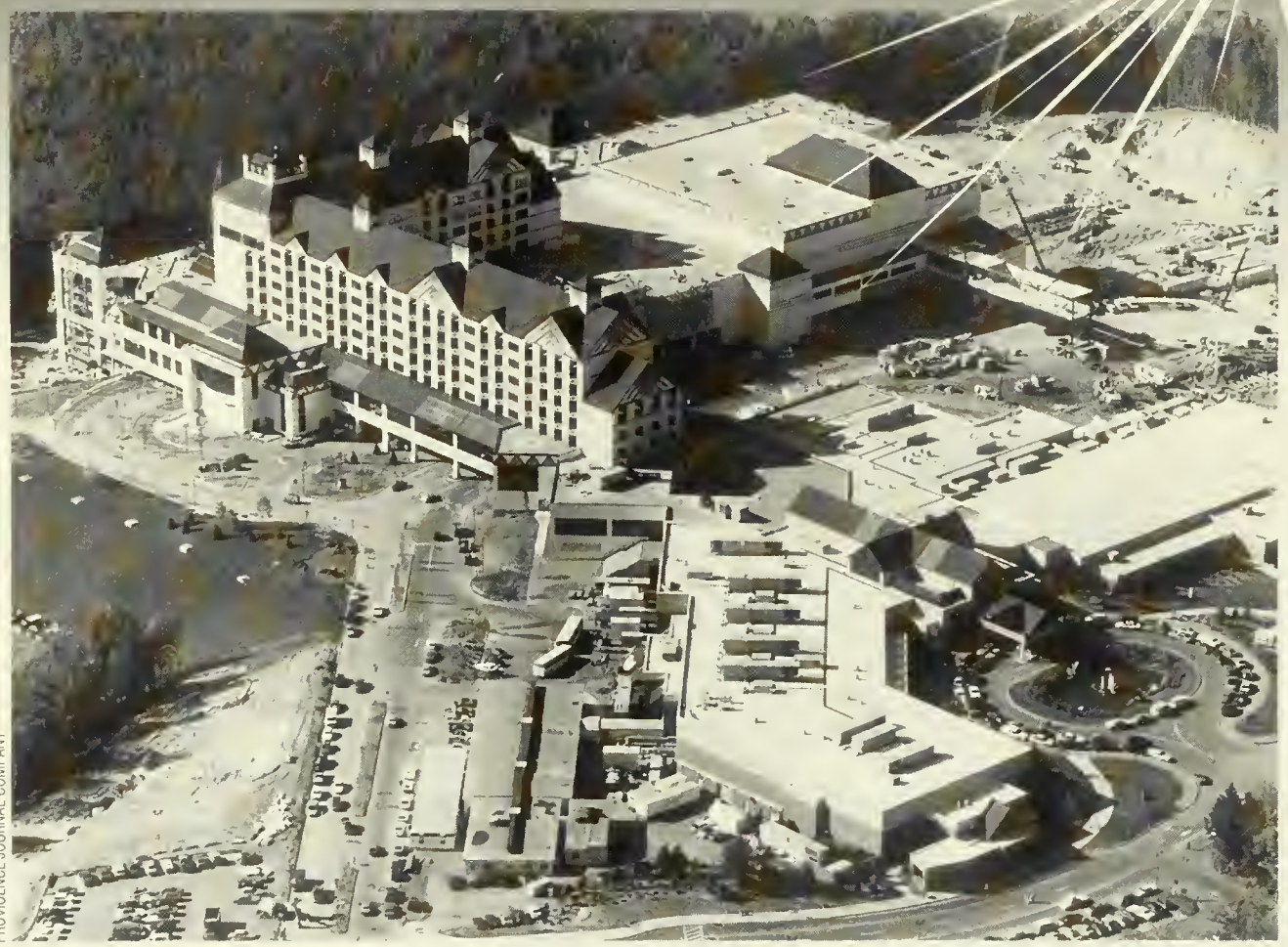
Levesque has also been active in digital and wireless data communications outside of GTE. Until a few years ago, he taught digital communications as an adjunct professor at Northeastern University, where he also advised graduate students. He has for several years served on telecommunications industry subcommittees working to set standards for such new technologies as digital cellular networks and personal communications service (see main story).

At WPI, he is a member of an advisory board for the Center for Wireless Information Network Studies and has been a longtime member of the Electrical and Computer Engineering Advisory Committee, a board made up of distinguished members of the electrical engineering profession who provide advice and guidance to the faculty of the Electrical and Computer Engineering Department. Levesque has also been active with the WPI Alumni Association, having served previously as chairman of the Alumni Fund Board and currently as a member of the association's Executive Committee.

"Through my collaboration with CWINS and the ECE Advisory Committee," Levesque says, "I hope to be able to provide some insights to WPI on the evolution of the wireless center and also to try to influence research directions and the development of the ECE curriculum. Wireless is one of the most exciting sectors of the telecommunications industry, and I believe the program at WPI will evolve to prepare students well for the challenges of the field."

—MD

ON THE FLASH TRACK



PROVIDENCE JOURNAL COMPANY

Two years ago it was rolling Connecticut woodland. Now it's the site of the largest gambling casino in the Western Hemisphere. Among the many people who helped bring this project into being, almost overnight, are nine WPI graduates.

BY RUTH TRASK AND MICHAEL DORSEY

IN *THE WIZARD OF OZ,* Dorothy and her newfound friends come upon the Emerald City rising dramatically from the edge of a field of poppies. That story comes to mind as one drives along Route 2 in southeastern Connecticut these days. After passing a series of small towns and speeding through a rural landscape of farms and forests, drivers are often startled to see a massive green, violet and white edifice looming just ahead through the trees.

The building is part of the rapidly growing Foxwoods Casino and Resort in Ledyard, Conn., reportedly the largest gambling casino in the Western Hemisphere. Owned by the more than 300 members of the Mashantucket Pequot Tribe, the complex of casinos, bingo halls and hotels has become a popular destination for gamblers and vacationers from all over the Northeast, and has provided a much-needed shot in the arm for the Connecticut economy.

The Foxwoods story began in 1982 when an act of Congress gave the Pequots the funds they needed to buy back about 800 acres of their ancestral land in Connecticut and place it in trust as a reservation, free of federal and state laws. To provide jobs for tribal members, the Pequots secured a federally guaranteed loan to build a bingo hall, which opened in 1986.

The hall, built by local contractor C.R. Klewin Inc., was highly successful, leading the Pequots to consider an expansion. The incentive to move forward arrived with the passage of the Indian Gaming Regulations Act of 1988, which authorized Native Americans to build casinos on their own land in states—including Connecticut—where some form of gambling (even charitable "Las Vegas Nights") is legal.

Foxwoods Phase II, an expansion of the bingo hall, was built next and in the spring of 1991 work started on Phase III—a 250,000-square-foot casino. Fearing the state of Connecticut might act to block the casino, the Pequots asked that it be finished in just over 200 days. Thus began a construction project so fast the term "fast-track" was inadequate to capture it. Instead, a new term was invented: "flash-track."

Phase IV—a second casino with a 312-room hotel and a 1,600-vehicle, four-level parking garage—was open by Labor Day in 1993. Another hotel, the Two Trees Inn, was built around the same time. Phase V, a new, 60,000 square-foot bingo and exhibition hall, was completed in April and Phase VI—an expansion to the parking garage—was slated for completion by Memorial Day. Along the way, the tribe has also built a state-of-the-art, one-million-gallon-a-day wastewater treatment plant, a community center, housing for tribal members, emergency services, and roads and other utilities.

In essence, a small city—one complete with 139,000 square feet of gaming space, a shopping concourse, restaurants, and a modern theater complex—has grown up in the Connecticut woods in just two years. And this huge construction project is not finished. In the planning stages are an Asian theme park complete with a replica of the Great Wall of China and a 305,000-square-foot museum and research center on North American Indians. And, there is the possibility of further expansion of the casino complex.

The mammoth casino and resort project was designed chiefly by New England Design Inc., in collaboration with architects Jeter, Cook & Jepson. Overseen by C.R. Klewin, the construction has involved the efforts of dozens of specialty contractors, engineers

AT FOXWOODS

and craftsmen who worked—sometimes around the clock—to keep up with the flash-track construction schedule.

Prominent among these companies are four firms owned or headed by WPI alumni, as well as a pump supplier that includes WPI graduates among its senior officers. In all, nine alumni working for these five firms have made their mark bringing to fruition what has been called the most exciting construction project in New England in many decades.

Among those who have been on the Foxwoods site since nearly the start is Raymond Cherenzia '73CE, the owner and president of Cherenzia & Associates Ltd. in Westerly, R.I. Cherenzia's firm has done civil engineering, site engineering, land-use planning and environmental work for various parts of the project. Ray works closely with his brother, Salvatore "Sam" Cherenzia, the president of Cherenzia Excavation, a longtime family business co-owned by Ray. Sam is also the father of Joseph Cherenzia '94.

Among the early work the Cherenzia brothers undertook for the Pequots were parking lots for casino patrons and employees—Ray did the site engineering and layouts while Sam did the excavation and construction. Ray says the work provided a crash course in flash-track construction. "Things moved so fast," he says. "On the first employee lot, we had our guys out there around the clock shooting elevations to keep up with the pace. They set up lights so we could work at night."

Cherenzia & Associates has also done layouts and as-built plans for other parking lots and for the water-line systems. Layouts show the builder every detail of a building site—from required grading to the location of structures, parking spaces, catch basins, lighting and signs; as-builts record everything about how a project was actually constructed for those who may need to dig or do other work at the site. The firm also did the surveying, site plans, layouts and as-builts for the community center, road system and tribal housing.

Ray Cherenzia, who is a registered professional engineer in Rhode Island, Connecticut, Massachusetts and Maine, and a licensed land surveyor in Rhode Island and Connecticut, worked for Seaboard Engineering, Northeast Constructors, and Metcalf & Eddy., and was town engineer in Westerly, R.I., before founding Cherenzia & Associates in 1981.

He says the firm has managed a kaleidoscope of projects, including work for such diverse organizations and companies as the town of Stonington, Conn., M.A.N. Roland, the Mystic Marinelife Aquarium, the Washington Trust Company Inc., and the A&P Tea Company. But he says his work at Foxwoods has been the most challenging and rewarding of his career.

Walking through the courtyard of the Two Trees Inn, for which his company did the site layout and as-builts, Cherenzia speaks with pride about seeing the products of his firm's efforts everywhere he looks at Foxwoods. "It's hard to believe that just a few short years ago there was nothing out here but that original bingo hall," he says. "It's nice to have been a part of it."

JANET WOODCOCK

"We had our guys out there around the clock shooting elevations to keep up with the pace."
–Ray Cherenzia

The Two Trees Inn was also a major focus of the work that Carl S. Cianci '82CE did at Foxwoods. He is a partner in Cianci & Cianci, consulting structural engineers in Hartford, Conn. His firm was founded in 1973 as Mayo and Cianci, P.C., by his father, Paul S. Cianci, and Glendon R. Mayo. Carl joined the company in 1983 and became a partner in 1985, when the firm took on its current name. It is registered to practice structural engineering in seven states and provides services to architects and owners for building designs and to contractors for design/build projects. Within the last 10 years the firm has also provided extensive forensic engineering services to the insurance industry.

Cianci did the structural engineering for the $20 million, 282-room Two Trees Inn, which was built a short distance from the casino complex. As the structural engineer of record, he was responsible for working with the architect, Friar Associates Inc., in preparing the structural design and construction documents showing how the structure would actually be built—often including what materials and details would be used.

On a 150,000-square-foot, three-story building, that process would normally be a challenging enough assignment. At Foxwoods, the job was made even more difficult by the accelerated schedule. Conceived in January 1993 and started in mid-March, the hotel had to be partially open by the July 4th weekend.

"It was the speediest project I've ever worked on—maybe one of the speediest projects ever built," Cianci says. "The pace was unbelievable. We literally had to do the structural design for the foundation before the design of the hotel was complete. We did the design for the hotel while the foundation was being poured."

The only way to build a hotel that fast, Cianci says, was to make it a modular building. A factory in Pennsylvania manufactured large boxes, each of which consisted of two hotel rooms and a section of hallway between them. The boxes, complete with

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Above, Jack Fitzgibbons, left, and James Carr of H. Carr & Sons in the Phase V bingo hall. Center, the shopping concourse under construction in 1993.

wiring and plumbing, were hoisted into position and fastened together on site.

Because the building was built on Pequot land that is not part of the reservation, it had to meet all of Connecticut's building codes, including seismic requirements passed in 1989. "As far as I know," Cianci says, "no one had ever done the structural engineering for a three-story modular building that had to meet wind and earthquake requirements."

Cianci also did the structural engineering for the community center, a beautiful 92,000-square-foot building that provides recreational and meeting facilities for members of the tribe. The steel-frame building is shaped like a bird; its wings house a pool and a gymnasium. "In these areas," Cianci says, "there are 90-foot clear spans bridged by 'glu-lam' trusses. The steel plates connecting the wooden trusses are shaped like arrowheads. Those spans presented some unique challenges."

"One day the fire marshal told them they had just four days to get a fire pump in every building or he would shut the project down."
–Robert Simonds

Cianci says another memorable part of his involvement with Foxwoods was working with the Pequots, who have been insistent that all of the buildings—including the casinos—harmonize well with their natural surroundings and impact the land as little as possible.

"On the first day of the community center project, all of the members of the project team came to look at the site with the tribal chairman," Cianci says. "He explained his ideas and said that the tribe was very concerned about not cutting down any more trees than necessary. Finally he said, 'Let's go for a walk in the woods.' We were all in our suits, so we thought he was kidding. But he wasn't. So we went for a walk in the woods."

Working with the Pequots was also an interesting experience for Hayes Pump in West Concord, Mass., a distributor for pump manufacturers, notes Robert L. Simonds '69ME, vice president of the company. Hayes supplied the majority of the pumps used at Foxwoods, more than $750,000 worth.

While much of the direct contact with the Foxwoods contractors was handled by the firm's Glastonbury, Conn., office, both Simonds and Gerry D. Nye '87MSM, a manager at Hayes, helped direct the continual flow of water, fuel oil, heating and fire pumps, as well as complete sewage lift stations, to the site.

Simonds says the requests for pumps were spaced out over the course of the construction, though Hayes did have to meet one particularly large order. "They were using more and more water at the site as the buildings went up," Simonds says. "One day the fire marshal told them they had just four days to get a fire pump in every building or he would shut the project down. It was a challenge, but we rounded up the pumps they needed to meet the deadline."

Foxwoods is not a typical casino. Instead of the neon and glitz one normally associates with Las Vegas-style gambling palaces, the buildings at the Ledyard resort are decorated in an understated but elegant style that reflects the Pequots' respect for nature and draws heavily on the tribe's traditional patterns and colors.

Large expanses of glass let visitors see the surrounding woods and hillsides, while waterfalls, rocks and acres of greenery bring a bit of nature indoors. Decorative panels on the building exteriors are based on the weave used in splint baskets made by the tribe for generations. And the purple and white dominating the color scheme mimic the colors of the wampum the Pequots once made from sea shells.

Two firms, H. Carr & Sons, an interior contracting firm with offices in Providence and Boston, and Jesmac Inc., a Providence contracting firm, have played major roles in bringing the interiors and exteriors of Foxwoods to life. James Carr '74CE is president of H. Carr; Jack Fitzgibbons '75CE is vice president. The president of Jesmac is Rick Rudis '76CE. The three became friends while they were fraternity brothers at WPI.

H. Carr & Sons, which was established as a family-owned plastering operation in 1930, currently offers a variety of state-of-the-art construction methods, including metal-stud partitioning and acoustical ceiling installation, Carr says. The firm has participated in more than 3,000 projects, not the least of which was Copley Place, the elegant upscale shopping and office complex in the heart of Boston.

To satisfy the architect's unique design for that 600,000-square-foot project, H. Carr developed a new type of plaster application that ultimately reduced the cost to the project's owner. Similar specialty interior con-

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Above, from left, Tom Purcell, Jim Granger and Rick Rudis of Jesmac Inc. In the background are some of the plastic panels the company installed.

struction methods were used at Foxwoods throughout the concourses, towering atriums and spacious rooms, where the Sheetrock, drywall, decorative fiberglass column coverings and other interior finishes also bear the Carr stamp.

A particularly distinctive section of the main concourse in the Phase IV casino is also a Carr product. One side of the concourse is lined with a long row of Colonial storefronts highlighted with pastel entrances, small-paned windows and fancy soffits. "We designed and built the storefronts using foam and fiberglass backup for the simulated plaster cornices and moldings," Carr says.

Similar work went into creating the streetscapes and interiors for Cinetropolis, a high-tech theme park inside the new casino. The entertainment complex includes a games arcade; a theater where viewers are taken on simulated flights on a jet fighter, among other adventures; a 360-degree theater that can be converted to a nightclub; and another hall that can be set up as either a 300-seat, giant-screen theater or a 1,400-seat arena.

H. Carr & Sons and Jesmac, on the Foxwoods site since 1991, have often worked around the clock, seven days a week, to stay on schedule as the project moved quickly from phase to phase. They have managed to stay on schedule—even ahead of it, at times—despite the flash-track pace and the vagaries of New England weather. "This was an especially tough winter," James Carr says. "There was lots of snow and for days at a time the temperature didn't reach double digits. Hard working conditions.

"We are currently running two eight-hour shifts a day," Carr says on a cool spring day as his crews and those of Jesmac busily work on the bingo hall and parking lot expansion of Phases V and VI. "We usually have a basic staff of 10—five site engineers and five superintendents. We also employ about 200 tradesmen."

Jesmac, which specializes in interior construction finishes, exterior wall finish systems and sprayed fireproofing, has become a major subcontractor in the New England area since its founding five years ago. The company has done work on the Pfizer Organic Synthesis Project and the Polaroid 11-X facility, among other projects, and has seen its annual sales volume top $20 million.

Also representing Jesmac on site are Tom Purcell '92MG and Jim Granger '86CE. Purcell was assigned to the project from the start to finish of Phases III and IV; Granger joined the project team in the summer of 1993. They've helped the firm complete a wide range of interior construction work at Foxwoods, including wall systems, sprayed fireproofing, light-gauge metal stud walls, gypsum wall systems and acoustical treatments. The company also did the interior work for the community center.

The distinctive and colorful basket-weave patterns that can be seen on the exteriors of the buildings in the main Foxwoods complex also reflect Jesmac's efforts. "We installed the exterior skin," Rudis says, "which is made up of plastic panels. We also installed a variety of other exterior finishings throughout the complex."

As the latest phases of the Foxwoods project move toward completion at their typically dizzying pace, the complex remains a study in contrasts. Outside, the air is filled with noise and dust as cranes swing steel beams and pallets loaded with construction supplies over the unfinished parking garage; front-end loaders fill dump trucks with earth; power tools roar as workers apply the finishing touches to the new buildings; and trucks and jeeps hurry from one construction site to another.

Inside, there is noise of a different sort as patrons place their bets at more than 300 gaming tables, set some 3,000 slot machines spinning, and wander through the bustling concourses, restaurants and hotels, seemingly unaware of the frenetic construction activity just beyond the walls.

"This was an especially tough winter. There was lots of snow and for days at a time the temperature didn't reach double digits. Hard working conditions."
–James Carr

These visitors, who arrive by the thousands each day in cars, limousines and buses, may never realize as they take in the grandeur of the complex and its surroundings that they are witnessing the products of a small miracle of modern construction. But for the people who made it all happen, including nine graduates of WPI, Foxwoods will always be a monument to their talent, craftsmanship, hard work, and willingness to do whatever it took to get the job done.

Saved by Schindler, Michael Klein Got on With His Life

By Michael Dorsey

It took more than four decades for Michael W. Klein, professor of physics, to feel ready to talk in public about his experiences as a prisoner in Nazi concentration camps during World War II and about Oskar Schindler, the man to whom he owes his life. Since the release of Steven Spielberg's Oscar-winning film about the German businessman, Klein has been talking about it a good deal as local groups ask him to come and tell, yet again, his compelling tale of horror, tragedy and survival.

Klein's journey into the Holocaust began in Janoshalma, Hungary, not long after his 13th birthday, when the Germans occupied his native country. Like all Hungarian Jews, Klein's family, including his father (a rabbi), his mother, and his 10 brothers and sisters, were ordered into the overcrowded ghetto of Baczalmas. For about six weeks they endured hardship and hunger.

The men were eventually sent to work with a Hungarian forced labor battalion. Then one morning the women and children were lined up and marched three miles to waiting cattle cars. Without water and with only the meager food they had carried with them, they rode for five days. "Conditions in the cars were horrible," Klein says. "It was June 24th when they loaded us in and it was very hot. But the worst part was that there was no fresh air—there were just two small openings at the ends of the car."

On the fifth day the train stopped. The doors of the cars were opened in unison as capos (prisoners who worked for the Germans) jumped aboard. With cries of *"Raus! Raus!"* ("Out! Out!"), they swung clubs with brutal force, beating the prisoners and driving them from the cars. This was the "welcome" all prisoners received to Birkenau, part of the infamous German concentration and annihilation camp in Auschwitz, Poland.

"The German SS were all around with dogs and machine guns," Klein says. "They said old people and women with children should go to the right and women without children and men should go to the left. We marched down a 10-yard path made by the train on which we had arrived on the right-hand side and high-voltage barbed wire on the left-hand side."

Being tall for his age, Klein went with the men. He noticed that his younger brother, David, was walking beside him. Remembering the SS officer's instructions, he sent him back to find their mother. Only later did he learn that in doing so he had sent his brother to his death, for, not fit for hard labor, the children and their mothers were taken immediatly to the gas chambers.

Klein was assigned to Barracks 16—the children's block—where a thousand children, their heads shaved, were crowded together, sleeping on the concrete floor and subsisting on a starvation diet. After seven weeks, Klein's father also arrived at Auschwitz and was assigned to the same camp as Klein. Auschwitz provided labor for nearby German factories and two days after his arrival the elder Klein was selected to go to work in the cement factory at Golleschau.

"I cried very hard," Klein says, "that just two days after I met up with him again he was going away. He said, 'I am not saying goodbye to you. We'll see what we can do.'

"The Germans wrote down the names of the people they selected—we didn't yet have our numbers tattooed on our arms. I went around and asked every prisoner if they wanted to change with me. There was a prisoner who had a brother in Auschwitz and wanted to stay with him. So I took his name—Goldberger, Arnold." [Klein says he appears on Oskar Schindler's list under this name.]

In leaving with his father, Klein escaped certain death, for the occupants of the children's block were gassed on Rosh Hashanah. But survival was by no means certain at Golleschau, which was a work-annihilation camp. Half of the workers died, were killed or were taken back to the gas chambers at Birkenau every three months. Klein's father would not survive his time at the camp and Klein worked with a broken hip to avoid being killed.

At Golleschau, rocks were mined from a mountain for use in the cement factory. Klein and his father, working side by side, helped build a cable cart line that was to be used to carry the stones to the factory. Not long after his father was taken back to Birkenau, Klein was injured when a lorry ran over his foot. He ended up in the camp hospital—in reality a room with no medical equipment or supplies where injured and sick prisoners were held.

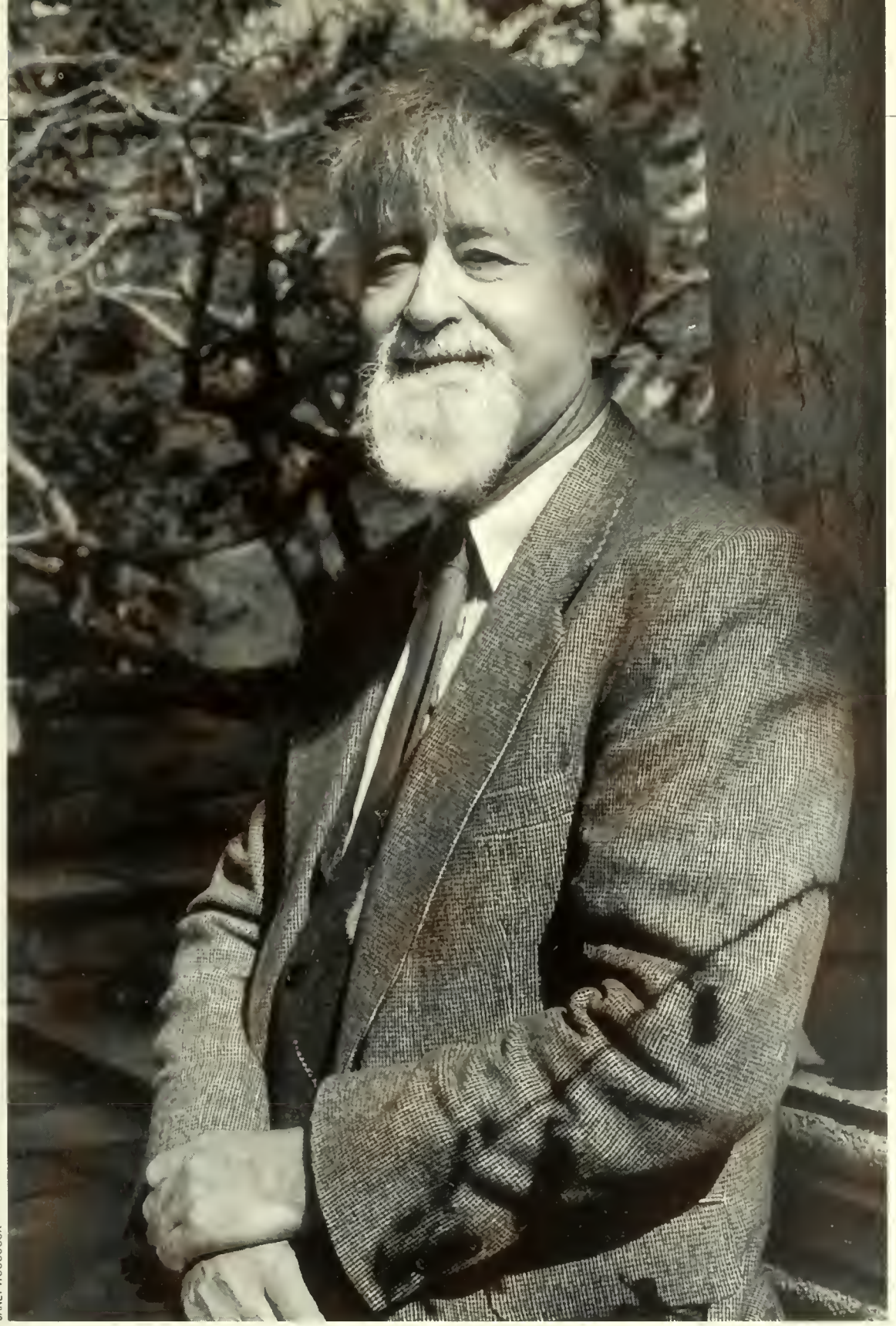
Normally the hospital was a temporary way station for prisoners destined for the gas chambers. But by late December 1944 the Germans, preparing to evacuate Auschwitz in advance of the arrival of Russian troops, stopped using the chambers. In January 1945 everyone in Klein's camp was evacuated—except for the 94 prisoners in the hospital.

"We were hoping that the Germans had all left and that we were free," Klein says. "But that same afternoon SS guards with machine guns walked in, so we knew our hopes were dashed."

Two days later the prisoners were loaded into cattle cars. The train moved intermittently for about three days. Then the locomotive was unhitched and the cars were abandoned on an isolated siding. A capo beat the other prisoners and forced them to scream for help every half hour. Several more days passed before a railway worker heard their cries and informed Oskar Schindler's brother-in-law, who worked for the German railway.

The brother-in-law notified Schindler and the next day a locomotive pulled the cars to the village where Schindler had his factory. Prisoners working for Schindler used blow torches to unfreeze the locks on the cattle cars. When the doors were opened, the 34 prisoners who had survived were fed hot farina. "Apparently Schindler knew that if we ate regular food we would die from diarrhea, because we had not eaten in eight days."

Hot farina arrived again the next morning and then the prisoners were led or carried to Schindler's camp. Klein threw off his filthy prison clothes and jumped into the hot



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showers Schindler provided. "I just enjoyed tremendously the sensation of hot water flowing over my face and over my body," Klein says.

The new prisoners were quarantined for three weeks. Still weak, Klein went to work in Schindler's factory making bullet casings. Klein says Schindler's "was the heaven of all camps." Workers were not beaten and were fed adequately. Each prisoner had his or her own bunk. But there were no medical facilities and most of the Jews who'd survived the trip with Klein to Schindler's camp ultimately died.

By spring, it was becoming clear that the war was winding down. On May 8 Schindler gathered everyone together to tell them it was finally over. "We were all standing on the machines trying to see him," Klein says. "He said, 'I know what was done to you. And I know what you went through you will never forget. But I hope you remember that this German did what he could."

The next day the Russians came and the prisoners were on their own. Klein developed a fever of 103, which he would endure for two years. He traveled in the back of a horse-drawn cart to Brno, Czechoslovakia, where he was hospitalized. He learned there that he had contracted tuberculosis.

Because he was Hungarian, he wasn't allowed to stay in the Czech hospital. With great difficulty, he worked his way back to Hungary, where he learned that two of his sisters had also survived the war. His older sister took him to the American Zone in Germany; he would remain there in a hospital for five years.

After two years, his temperature was low enough for him to begin to read. "I concentrated all my energies on trying to educate myself," he says. "I taught myself German, which became my best language. I got books on math and physics and taught myself fractions and algebra."

When he was well enough, Klein came to the United States. The Korean War had started and many colleges were admitting as special students qualified young men and women who had not completed high school. Klein earned a bachelor's degree in engineering physics at the University of Colorado, graduating at the top of his class, and went on to earn a Ph.D. in theoretical physics at Cornell.

While at Cornell he met another Holocaust survivor, who would become his wife; today they have two children and eight grandchildren. A professor at WPI since 1979, he has also developed an international reputation for his work in theoretical physics, especially his pioneering work on explaining certain anomalous low-temperature properties of glasses.

"I have taken on as my motto, 'Never Look Back,'" he says. "I have looked forward and tried to establish for myself a normal life. It is this attitude that has helped my wife and me become active and useful members of society, rather than crying over the past."

But Klein has looked back, too. In addition to his talks, he has written several articles about his experiences at Auschwitz and is at work on a book about his life. To verify his memories, he has taken trips back to Poland and Hungary. On a visit to the cement factory with his oldest son, he found it unchanged after nearly 50 years. "I could close my eyes and take him from place to place," he says. "I remembered every detail so well. These are things that are engraved in one's mind."

Since *Schindler's List* opened, Klein says he has been frequently asked his opinion of its central character. "He clearly started out as someone trying to profit from the Jews by using their money to enrich himself," he says. "But as time went on he became more and more dedicated to saving the Jews who worked for him. He did that by drinking and womanizing with the SS—with the murderers.

"People ask me, 'Did this make him a good man or a bad man?' I say if he hadn't done what he did he couldn't have saved anyone, so it doesn't really matter. I think he was a great man."

'Brother-Sister'
Co-Ed Dorms
Riley' Rules Sanford Riley Hall
INRI
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WPI Journal

WORCESTER POLYTECHNIC INSTITUTE

SUMMER 1994

THE INTERNET

Bringing the World to Your Computer

Cover: Cut-paper illustration by Laura Tedeschi. Story on page 8.
This page: In the spring, work began on the new 20,000-square-foot addition to Higgins Laboratories. This view shows the addition's second floor shortly after the steel frame was completed. The outer wall of the original building can be seen at left. Photo by Janet Woodcock.
Back Cover: The lush green of summer surrounds the entrance to Atwater Kent Laboratories. Photo by Janet Woodcock.

WPI Journal

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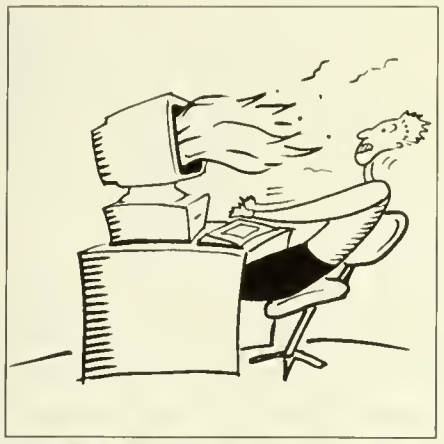

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Wanted: A Helping Hand

Yvonne Harrison, director of the Career Development Center, says there are a number of ways alumni can get involved in helping students and other alumni plan and shape rewarding careers.

JANET WOODCOCK

The Spring 1994 *WPI Wire* included a story on the vital role that alumni, as members of the Alumni Admissions Program, play in attracting and admitting new WPI students. Alumni, of course, can also help by letting the Admissions Office know about talented high school students who might be interested in what WPI has to offer and by talking to high school students, teachers and guidance counselors about the Institute. WPI can also use the help of alumni when it comes time to help students plan and launch their careers.

As this issue of the *WPI Journal* goes to press, about a third of the Class of 1994 is still looking for work. With corporate downsizings and realignments, and the continuing economic shocks of the recent recession, starting a career has become a far more challenging and uncertain task for graduates of engineering and science programs. The changing economy has also left many other WPI graduates seeking new jobs or rethinking their career plans.

We thought this would be a good time to look at the changing employment picture for our graduates and at how the Institute is responding to that shifting landscape. Our coverage begins on page 20. As you'll see, WPI's Career Development Center, once primarily a placement service, now offers a wide range of career planning services.

It also begins working with students long before they graduate—and continues long after they graduate. In fact, the center offers alumni many of the same services available to undergraduates, including access to job postings and a jobs hot line, a résumé referral service, a library of literature and videotapes on corporations, and one-on-one counseling.

This changing focus began about seven years ago when the WPI Alumni Association launched a new initiative called Career Connections. The program was designed to fill a real need among students and graduates for sound advice on career planning and other career-related issues.

The association also recognized that WPI's alumni body represents a tremendous resource, constituting 20,000 men and women with personal experience in career planning, many thousands of employers with jobs to fill, thousands of potential clients and associates, and thousands of professionals with valuable contacts.

To bring these alumni together with each other and with current students, Career Connections, in conjunction with several WPI offices, created and funded the highly successful Career Day, an annual event that featured workshops, seminars, panel discussions and lectures on career-related topics. Other Career Connections initiatives included workshops and panels for alumni in specific disciplines and a program that helps underclassmen choose a major.

The programs were great successes, notes Sharon Davis, director of alumni programs. Each garnered a high turnout and enthusiastic comments from participants. Many of those initiatives have been incorporated into the programs of the Career Development Center, but that doesn't mean that the Alumni Association has set aside its interest in career planning.

"Quite the contrary," Davis says. "In fact, the first goal of the association's new Master Plan is to continue to help undergraduates and alumni in developing lifelong career-related skills and to continue to develop career-related services."

The association has two new initiatives. It will fund the installation of a computer at the CDC for use by alumni. The computer will let users tap into CDC services, such as Résumé Expert Plus (see page 24), and prepare cover letters and other correspondence to prospective employers.

The second initiative is a new database program that will match alumni with other alumni and undergraduates who are seeking information on careers or companies. This new Alumni Network will be made possible by the energy and talents of a host of alumni volunteers, Davis says. Those volunteers were identified through the survey done as part of the publication of the new *Alumni Directory*. The survey asked alumni if they would be willing to volunteer to help out with the Institute's career services. "We were pleasantly surprised to get 1,200 positive responses," she says.

Also pleased was Yvonne Harrison, director of the Career Development Center. Harrison says her office is keen to involve as many alumni as possible, and says the Alumni Network will help. For example, alumni can let the CDC know when they learn of new job openings. Through a program called Professionals in Action, they can help recent graduates learn more about their disciplines.

"This is a program for underclassmen who want to know more about particular

careers," she says. "They spend a day or two with an alum to see what his or her work is really like. Alumni can also make themselves available for informational interviews, which let students ask about their work, about how they've managed their careers, and about the kinds of opportunities available in their fields."

Harrison says she also hopes to start a mentoring program that will match up alumni with specific underclassmen. "The alumni would meet with the students once or twice each year to make sure they are taking the steps that will make them more marketable to employers when they reach graduation." Also under consideration is a host program, in which alumni living in different parts of the country would talk to students doing job searches or interviewing in those areas about the quality of life, employment opportunities, and so on.

The CDC also needs help from alumni in setting up summer work opportunities, co-op assignments and internships. "About a third of each class applies to do a co-op, but we simply don't have enough opportunities in most fields. We need to expand our undergraduate work programs, and we're appealing to our alumni for help in doing so."

Alumni can also play an important role in helping graduates find permanent employment—especially within their own companies. That not only means hiring WPI graduates for open positions, but making sure that others within their organizations understand the value added by a WPI education.

"Alumni should be our most important recruiting source, because they already know what our program is all about," Harrison says. "They understand it, and they can sell it internally to their counterparts and peers. This is especially important at organizations that aren't familiar with us or haven't had as much exposure to our graduates.

"Our alumni know the value of their own education. They know that WPI graduates possess the qualities their companies are looking for—things like a team orientation and global experience. They can do a good job of raising WPI's visibility within their organizations. And this can have a great return. After all, when you are looking to build yourself up in an organization, you have to also build up your background, and that includes your university."

—Michael Dorsey

LETTERS

This Dog Won't Hunt

To the Editor:

Re: "To Alma Mater, Good and True" (Winter 1994). Let me say right off the bat, I think the present WPI alma mater is a dog.

The whole thing is too long and cumbersome, the music is difficult to remember, and the words are even more difficult to remember and are at odds with the character of the school today.

Just look at the photograph that accompanied the article (reprinted here). The WPI Student Alumni Society is singing the Alma Mater, and see how many of them are having to refer to the words. Would this

happen at Dartmouth or Princeton or Cornell? No way.

Although our class was drilled in the singing of this nightmare, I doubt if many remember the tune and the words. I don't myself, but I can sing the Princeton and Cornell alma maters by heart. Their words and music are uncomplicated and memorable.

Take a poll of the total WPI alumni and see how many could sing our alma mater by heart. I attended the 50th Reunion of my class in June and almost all of the graduates at the Reunion Luncheon had to read the words in the program to cope. In fact, Alex Papianou '57 announced that he would lead the singing since he was probably one of only two alumni there who knew the tune!

The present alma mater is an Edsel and should be given an honorable retirement. A new one should be chosen that would have no more than eight lines and an uncomplicated melody that lends itself to harmony.

Let's have a competition for a decent alma mater that can be presented to the student body, the faculty, the administration and the alumni for their approval—not just to a committee.

—Erling Lagerholm '44
Carmel, Calif.

Boyd Taught Students How to Think

To the Editor:

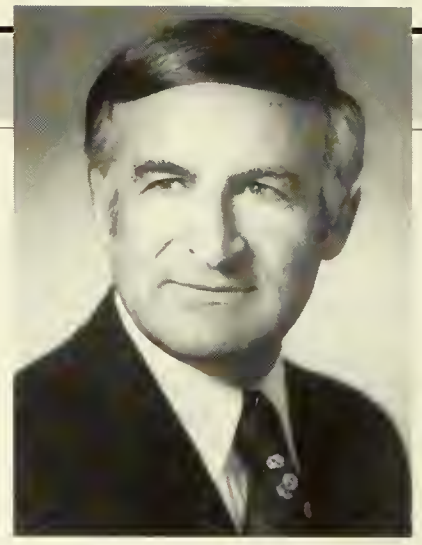
My husband and I are both members of the Class of 1989. We were so pleased to see such an eloquent chronicle on Professor Jack Boyd ("The Privilege of Teaching," Winter 1994). I am truly saddened that Professor Boyd will not be a key player in the development of "Plan II." His was the class that taught students how to think. His enthusiasm and commitment are catching even today. Professor Boyd is the epitome of everything I valued at WPI.

Many WPI students could have attended schools like MIT, but they wanted a school with excellent teachers, not researchers who were inaccessible to them. I sincerely hope that the ongoing push at WPI for advanced research will not be at the expense of superior teachers.

Undergraduates need mentors and professors who allow—and encourage—students to go to them with problems, to freely ask questions, and to even share a joke with. Professor Boyd is that type of mentor. His humility and caring for his students is real. I never once went to his office without feeling better when I left.

I am disappointed that WPI will no longer be home for Professor Boyd. I wish him all the happiness in the world and thank him for the part he played in my total education. WPI will never be the same without him.

—Kathleen (Murray) King '89
Stow, Mass.



Academia is Shortchanging New Engineers

By Morton S. Fine '37 P.E.

As a result of a long and intense involvement with engineering registration, I have reached the conclusion that, year after year, new crops of engineering graduates are being shortchanged by the profession and by academia. These students are not being given the knowledge they need about engineering licensure and its processes, with the result that comparatively few take the first step toward their professional registration. That's unfortunate for the students and for the stature of the engineering profession.

It is ironic that only about one in four highly qualified engineers in this country may write the letters "P.E." (professional engineer) after their names. In sharp contrast, virtually all physicians may use the title "M.D." (medical doctor), and they do so with pride. The title is prestigious and commands the respect of the public.

Persons who have earned a doctorate in medicine may use their professional title whether or not a state subsequently licenses them to practice. But while the engineering profession, through the Accreditation Board for Engineering and Technology (ABET), sets the requirements for the baccalaureate engineering degree, the right to use the title P.E. is determined by the states.

States grant professional engineering licenses to those who may offer services to the public. But thousands of thoroughly qualified engineers have no need for such a license. They are professional engineers in the best sense of the term, but they have little incentive to pursue the prestigious P.E. title and the strong identification with the profession that the title bestows. They also cannot qualify for the full-member status of their professional societies.

The states' role in licensing engineers began in Wyoming in 1907. Officials needed to identify people who were qualified to write descriptions of water rights, but what began as an effort to regulate land surveyors blossomed into regulation of the entire engineering profession. As other states embraced the Wyoming concept, each wrote its own legislation, created state boards with the necessary jurisdiction, and adopted various rules and regulations. By the close of the 1950s, every state had an engineering statute.

The registration process that emerged does its job. It enables the states to determine whether persons possess the minimal competence to offer engineering services to the public, whether that means designing or building dams, bridges, power stations, ships, planes, trains or skyscrapers. But it also creates a narrow definition of Professional Engineer that excludes most people in the profession.

Today, most engineers who seek state registration are graduates of college and university engineering curricula accredited by ABET. They begin the process of seeking professional recognition by taking the F.E. (Fundamentals of Engineering) examination, the first of two rigorous exams typically encountered on the road to professional status.

The F.E. exam is considerably more difficult than the Professional Engineer exam, which is normally taken only after an engineer has had a minimum of four years of qualifying work experience. Because the F.E. exam covers a broad range of principles that undergird our profession, it is best to take it at or near the end of the senior year in college. Passing the exam becomes increasingly difficult as one's college years recede. This fact alone discourages most engineers from taking it when more than a few years have elapsed since graduation.

Because the best time to take the F.E. exam is in college, ABET is in a commanding position to facilitate the process leading to the P.E. title. ABET should mandate, as a condition of accreditation, that engineering schools require all senior engineering majors to take the F.E. exam—take, not necessarily pass. Most seniors will pass the exam, but everyone should be required to take it.

This requirement will start all ABET-accredited graduates on the road to becoming P.E.s. It will also be an acknowledgment by ABET that becoming a P.E. is one of the major goals of an engineering education, just as a major goal of an education in law is the attainment of the J.D. degree and the title "attorney," and of an education in medicine the M.D. degree and the title "doctor."

There will be resistance to this new requirement. Most people—including many engineering faculty members—think of the F.E. exam only in connection with registration and private practice. Since most such educators in this country don't need registration and do not themselves possess the P.E. title, they are little motivated to encourage seniors to take the exam.

Furthermore, to most seniors the need for registration seems remote. Most are far from certain, at this stage in their still-maturing careers, whether they will have a need for a license. They naturally see registration as a bridge they can cross if they come to it. Thus they must be required by the more experienced of us to get the F.E. exam out of the way while still in college.

This accreditation requirement by ABET would do more than any other single action our profession could take to facilitate the achievement of—and thereby broad use of—the P.E. title. It is a step wholly within our profession's jurisdiction to take. We can take it without worrying about state regulations and the related complexities of politics. Truly, such a step would symbolize the determination of our profession to make professional status more available to all engineers and to bring to our profession the unity and the recognition it needs and deserves.

—Fine spent 20 years on the National Council of Examiners for Engineers and Surveyors, the organization that prepares and manages the F.E. and P.E. exams on behalf of state boards of registration. He was president of the council from 1974 to 1975 and executive director from 1976 to 1982. In the 1960s and 1970s, he served 12 years on the Connecticut State Board of Registration for Professional Engineers and Land Surveyors. This article is an excerpt from a larger work by Fine. The entire work can be obtained by writing to him at P.O. Box 551, Bloomfield, CT, 06002.

Light at the End of the Tunnel for CNG-Fueled Vehicles

The federal Clean Air Act of 1990 and the Energy Policy Act of 1992 have put pressure on cities like Boston to find ways to reduce air pollution caused by the millions of vehicles that use their roads, bridges and tunnels. One attractive solution to this problem is to convert a healthy share of those vehicles to cleaner-burning fuels like natural gas.

In Boston, however, efforts to convince owners of fleets of vehicles to convert their cars, vans and buses to cleaner fuels have come up against a serious roadblock—restrictions on travel through the city's longer underpasses and tunnels, including the tunnels that provide the primary access under Boston Harbor to Logan International Airport.

The restrictions, imposed by the Boston Fire Department, grew from concerns about the potential danger of fire and explosion posed by accidental releases of gaseous fuels within the tunnels. Now, thanks to a yearlong study by researchers in WPI's Center for Firesafety Studies, concerns about one such fuel—compressed natural gas (CNG)—have been allayed.

Comparing the relative hazards posed by accidental fuel releases from vehicles powered by CNG and gasoline, the study concluded that gasoline spills pose a more significant fire and explosion hazard in ventilated tunnels. As a result, the Boston Fire Department is removing its objection to CNG-fueled vehicles for all tunnels and underpasses that have effective mechanical ventilation.

The WPI study was funded by a two-year, $88,400 award from the Massachusetts Highway Department, which is being administered by Bechtel/Parsons Brinckerhoff (B/PB), the prime contractors for a major project to place Boston's Central Artery underground and build a third tunnel under Boston Harbor. Robert G. Zalosh, professor of fire protection engineering, is the study's principal investigator.

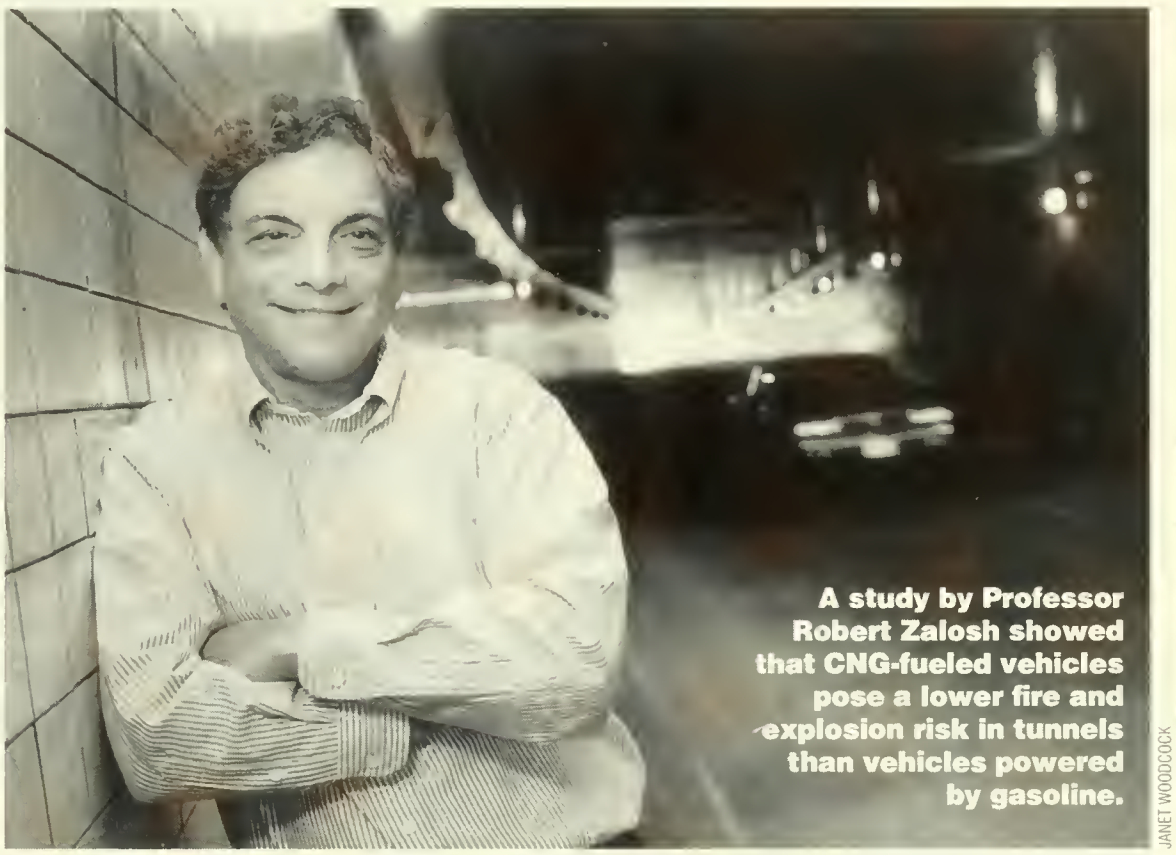
The results were reviewed by a steering committee made up of representatives of the Boston Fire Department, the State Fire Marshal, and the Massachusetts Division of Energy Resources, Executive Office of Environmental Affairs, Highway Department and Turnpike Authority. It was the steering committee's recommendation that led to the Fire Department's decision.

In the next phase of the WPI study, the research team will review the potential hazards posed by vehicles fueled by liquefied petroleum gas (LPG) and liquefied natural gas (LNG).

"Each fuel has unique characteristics, so it is important that we assess each individually," Zalosh says. "For example, unlike CNG, LPG is heavier than air and won't disperse the same way in a tunnel. LNG is stored at cryogenic temperatures; when it spills onto the road surface, it boils rapidly into a vapor. A key part of the study involves calculating the vaporization rates and vapor release rates for these fuels in simulated incidents, such as a ruptured fuel line."

ized tank as a result of a break in the fuel line near the tank, and how fast gasoline would spill and spread across the floor of a tunnel after a fuel-line break. These were chosen as the most serious types of releases likely to occur as a result of a traffic incident.

Knowing the release rates for the two types of fuel, Zalosh and his students used computational fluid dynamics software to determine the size and duration of the vapor cloud that would result from each type of spill. They determined that, under most conditions, the vapor cloud from a CNG accident would be smaller and would dissipate far more quickly than that from a gasoline spill from a comparable vehicle.



A study by Professor Robert Zalosh showed that CNG-fueled vehicles pose a lower fire and explosion risk in tunnels than vehicles powered by gasoline.

JANET WOODCOCK

In recent years, studies of CNG-fueled vehicles have also been sponsored by the cities of Baltimore, New York and Toronto; like the WPI study, these concluded that CNG restrictions should be relaxed or removed, Zalosh says. "What makes our study unique is that we have done a one-to-one comparison of gasoline and CNG using a consistent methodology and employing the same criteria for each fuel. We use the size and duration of the vapor cloud resulting from a gasoline spill as a benchmark measure of the existing hazard posed by conventional-fueled vehicles."

In the study, Zalosh and two graduate students developed computer models for a variety of accident scenarios involving fuel leaks in tunnels of different sizes and with different ventilation configurations. The models were used to compute how quickly natural gas would be expelled from a standard pressur-

In fact, they found that the vapor cloud from a CNG-fueled van would not extend much beyond the immediate vicinity of the van, or a few feet from the ceiling of the tunnel, depending on how the tunnel is ventilated. A leak from a bus would produce a larger vapor cloud, but the cloud would disperse completely within about five minutes. A gasoline spill, on the other hand, would produce a vapor cloud over a much larger area and the cloud would persist for much longer than the natural gas cloud. Making matters worse, Zalosh notes, gasoline vapor remains flammable at lower concentrations than natural gas vapors and therefore must be diluted to a lower concentration before it becomes safe.

Zalosh says the study demonstrated that the transverse ventilation configuration used in most tunnels, including the major traffic tunnels in Boston, aids in the disper-

sal of a natural gas vapor cloud while actually enhancing the formation of a gasoline vapor cloud. He says natural ventilation and the horizontal air movement caused by traffic are also effective in rapidly diluting any natural gas released into a tunnel. In a separately funded follow-on study, the WPI researchers will measure the air flows in certain unventilated tunnels and underpasses to help determine whether they may also be opened to CNG-fueled vehicles.

Tapping Into Clean Water at a Reasonable Cost

When someone turns on the faucet in the Boston area, the water that comes out probably originated far away in a system of reservoirs that starts with the massive Quabbin some 60 miles to the west of the city. Through careful watershed management, the Massachusetts Water Resources Authority (MWRA) and the Metropolitan District Commission have been able to supply clean water to their customers in Eastern Massachusetts from this surface water system without the need for expensive treatment plants. But that could change.

Under new amendments to the federal Safe Drinking Water Act, communities that get their water from reservoirs will have to build filtration plants over the next few years unless their water meets several "avoidance criteria." They also require improved disinfection and corrosion control for water systems. In Massachusetts, the total cost of building new treatment plants is estimated at $1.1 billion. For the MWRA, the cost is $400 million.

During the past few years, the MWRA has been looking at various treatment options for the Wachusett Reservoir, a major link in the chain of reservoirs that supplies Boston. It is simultaneously pursuing a dual track for treatment consisting of filtration and watershed management plus nonfiltration options. The agency has launched a study that compares treatment options that use filtration with an option that involves just disinfection to kill bacteria (water from the Wachusett does not meet the avoidance criteria for coliform bacteria) and corrosion control. The goal of the study is to find a way to meet the federal requirements at the most reasonable cost.

As part of this study, Camp Dresser & McKee has awarded WPI a one-year, $82,000 contract to conduct a water-quality analysis of the reservoir and to help run a demonstration water treatment plant that will be used to evaluate various treatment schemes. Frederick L. Hart, associate professor of civil engineering, is the principal investigator for the study. Graduate students Peter J. Grabowski and Gregg Giasson will take and analyze the water samples and operate the demonstration plant.

MICHAEL DORSEY

From left, Professor Fred Hart and graduate students Peter Grabowski and Gregg Giasson in the demonstration water treatment plant at Wachusett Reservoir.

Hart says the students will collect water samples monthly at various locations in the reservoir to see how water quality varies with the seasons. The students will also obtain samples under a number of specific conditions, such as high storm runoff. The samples will be analyzed for a variety of factors, such as bacteria, organic and inorganic particles and dissolved matter, nutrients, and color.

In the second phase of the study, Grabowski and Giasson will spend 16 hours a day, five days a week, at the reservoir operating the demonstration water treatment plant, which contains a number of treatment units that can be connected in various combinations. This will allow the students to create four different treatment trains, ranging in complexity from one that includes oxidation, mixing and coagulation, flocculation, clarification, disinfection, and filtration, to a simple scheme employing just disinfection, oxidation and adsorption. (Hart says studies have shown that oxidation often enhances filtration.)

In addition to operating the equipment, the students will collect data on the plant's operation and the quality of the water at various stages in the treatment trains. They will then analyze and interpret the data, which they, Hart, and Camp Dresser & McKee will use to make recommendations to the MWRA about the best course of treatment for the Wachusett. "The whole idea," Hart says, "is that from this work they will find out the quality of the raw water, the treatment options that best match that quality, and the costs involved in those options. They can then go ahead with a preliminary design for a water treatment plant."

Where the Rubber Meets the Road

On the surface, an asphalt runway might seem to have little in common with a high-tech space mirror. But to a research team at WPI, the surfaces of these disparate materials present an identical challenge—how to engineer things that are smooth and rough at the same time.

The team, Christopher A. Brown, associate professor of mechanical engineering, and graduate students William A. Johnsen (runway project) and E. Michael Shipulski (mirror project), is looking for solutions to this problem with two grants from NASA: a $77,000 award toward what is expected to be a three-year, $194,000 grant from NASA's Langley Research Center to study runway topography; and $44,000 toward what is projected to be a three-year, $66,000 grant from NASA headquarters to help engineer a collapsible parabolic mirror NASA plans to use

to create high temperatures in space by concentrating solar energy.

"With the runway, you want a surface that is smooth to minimize wear on airplane tires," Brown says, "but rough to maximize friction, which keeps planes from skidding off into harbors. Tire wear is a problem for aircraft; some military planes get fewer than 20 landings on a set of tires. But a runway that's too smooth might cause planes to hydroplane when it rains.

"The mirror will be made from metal coated with a polymer to protect it when the whole thing is folded up. The interface between the polymer and the mirror is where the light will be reflected. This region must be smooth to reflect light cleanly without scattering. But it must also be rough so the metal and the polymer can be glued together."

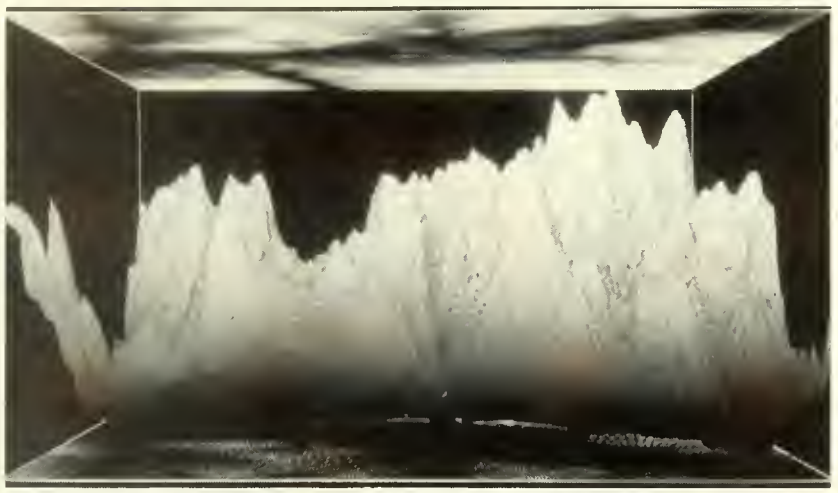
The key to pulling off this trick, Brown says, is the fact that the same material may appear smooth or rough depending upon the scale at which things interact with it. A runway may seem smooth to a wheel rolling down its surface, but rough to the tread on the tire. A mirror may be smooth at the scale of light waves, but rough at the scale of the glue molecules that bind the metal and polymer together.

To better understand this relationship between topography and behavior, Brown has turned to fractal analysis, a type of non-euclidean geometry. Fractals are complex shapes that can be divided into smaller and smaller parts, each of which is similar in appearance to the part from which it was taken—much as a leaf of a fern is virtually identical in appearance to the whole fern. This is called self-similarity.

Fractals have proven useful in describing natural phenomena like clouds, coastlines and mountains that are not composed of simple geometric shapes and which exhibit self-similarity. For example, seen from a short distance away, a mountain appears to be a collection of small hills on a larger hill. As one moves closer, each of the smaller hills turns out to have still smaller hills, which in turn have still smaller hills.

Brown first began to consider the application of fractals to the engineering of materials in the late 1980s, when he was head of the Mechanical Surface Treatment Group at the Swiss Federal Institute of Technology. "In manufacturing surfaces we see similar phenomena," he says. "On a ground surface, for example, you might see little scratches on big scratches. Fractals began to look like an answer searching for a question.

"Fractal analysis is a way of deriving order out of chaos. The geometry of a runway, for example, is a jumble. If you tried to apply euclidean geometry to it, you'd have a difficult time. Like mountains, runways also exhibit self-similarity. If you get close enough, you can't tell if you're looking at a runway or the Himalayas."



MICHAEL DORSEY

Bottom, graduate student William Johnsen gathers data on the topography of a runway sample with a laser profilometer. Using "fractal recipes," one can analyze the data to see how the apparent smoothness or roughness of a surface changes as the scale at which one interacts with it changes (top).

To apply fractal analysis to a surface, one must first collect detailed information about its topography. To gather information about runway surfaces, Brown and Johnsen are using a laser profilometer built by Mark W. Mattei '94 and Matthew S. Mercer '94 as their Major Qualifying Project. The device bounces a narrowly focused laser beam off of the sample to measure the height of up to a million points on the surface of a sample roughly 6 inches on a side. Data on the mirror surface is collected with an atomic force microscope, a device capable of resolving individual atoms.

The data is fed into a computer and fractal "recipes" are applied to it using patented software developed by Brown and Pat D. Charles '92, now a hardware engineer at Digital Equipment Corp. (further work on the program is being done by Bruce Meacham '96). The analysis enables the researchers to observe how the apparent smoothness or roughness of the material changes as the scale at which one interacts with it changes. For example, as one moves closer to a surface, its apparent area seems to grow, just as the apparent length of a coastline seems to increase as one moves closer and increasingly smaller inlets and projections become visible.

Brown says that if one plots the apparent area versus the scale of interaction, the resulting curve rises steadily for a time, and then takes a sharp upward turn. This, he says, is the point where a surface seems to change from a smooth to a rough texture. He says the next step will be designing runways and mirrors so that this smooth/rough crossover falls between the two scales of interaction—between the scales of wheels and tire tread, and between the scales of light waves and glue molecules.

But first, Brown says, the researchers will need to more precisely identify those individual scales. For runways, Brown and Johnsen will compare the information they gather about the topography of different types of runways with information in a NASA database on tire wear and friction on those same surfaces. For the mirror, Brown and Shipulski will compare their data to measurements of how well various combinations of metal and polymer, made with a variety of manufacturing techniques, reflect light. To make these measurements they will use a laser apparatus built by Andrew R. Watzke '95 and Jason Truscott '94 as their MQP.

"With our measurement techniques, we are going to be able to understand more about the topography of these materials—and at finer scales—than has ever been possible before," Brown says. "We feel that this understanding will lead to some real advances in materials engineering."

Net Assets

By Michael W. Dorsey (mwdorsey@wpi.wpi.edu)

Unless you live in an isolated corner of the globe or rarely pick up a newspaper or magazine, you've probably heard of the Internet. You may even be one of the more than 30 million people around the world who have stepped over the electronic threshold into cyberspace. But if you've not yet made the leap, you might be wondering what all the fuss is about. Or perhaps you've decided to try the Net on for size, but don't know where to start or what to do once you get connected.

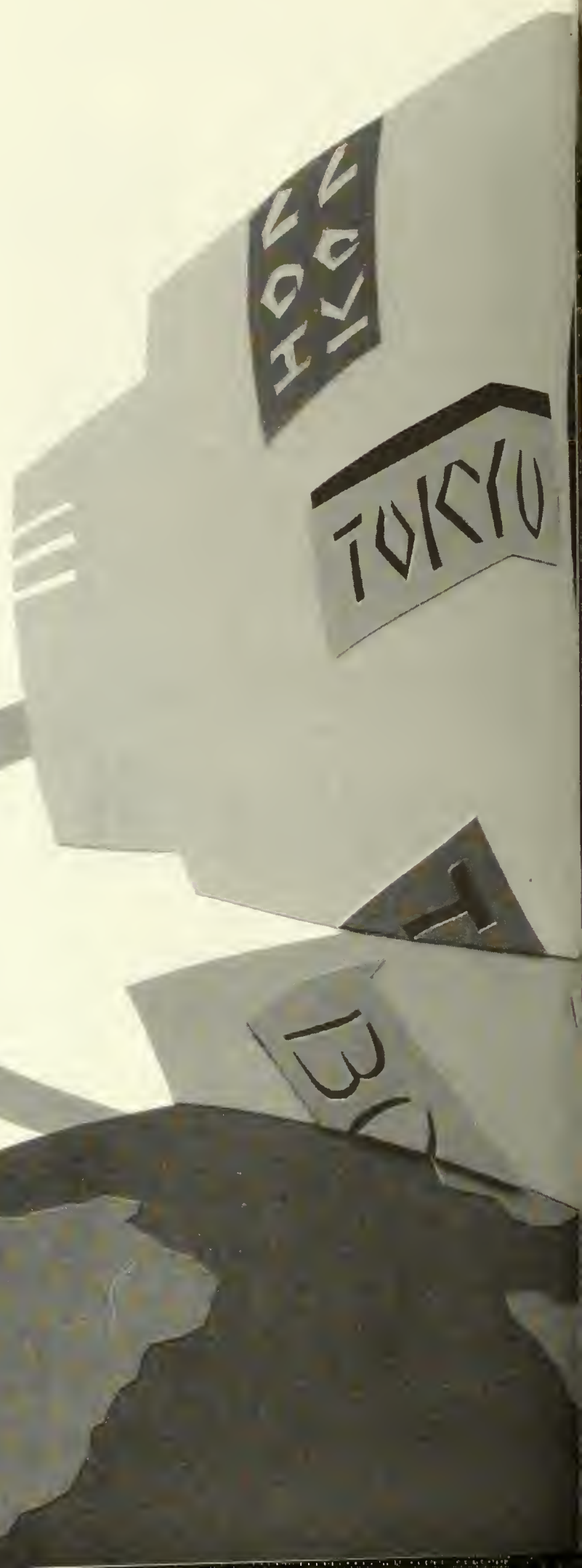
In the pages that follow, you will learn about the experiences of a few WPI students, faculty members and administrators who have used the vast resources of the Internet in a variety of ways—some typical and some quite innovative. These glimpses of life on the Net are intended to demonstrate, in a small way, what all the fuss is about. You will also find a brief look at what's out there and a beginner's guide to how to get at it.

Before we begin, though, a caveat: the Internet is many things to many people, but one thing it is not is user friendly. In this brief article, we can't begin to tell you all you'll need to know to join the ranks of cybernauts. To top it all off, the Net is a work in progress. Things move, disappear and change—all the time. You'll need a good guide—preferably a friend who's had some Internet experience. A good book is also essential (see page 15 for some recommendations). But most of all, you'll need patience and flexibility. But don't let this cautionary note discourage you from joining the Net community. The learning curve is a little steep at first, but the rewards are worth it.

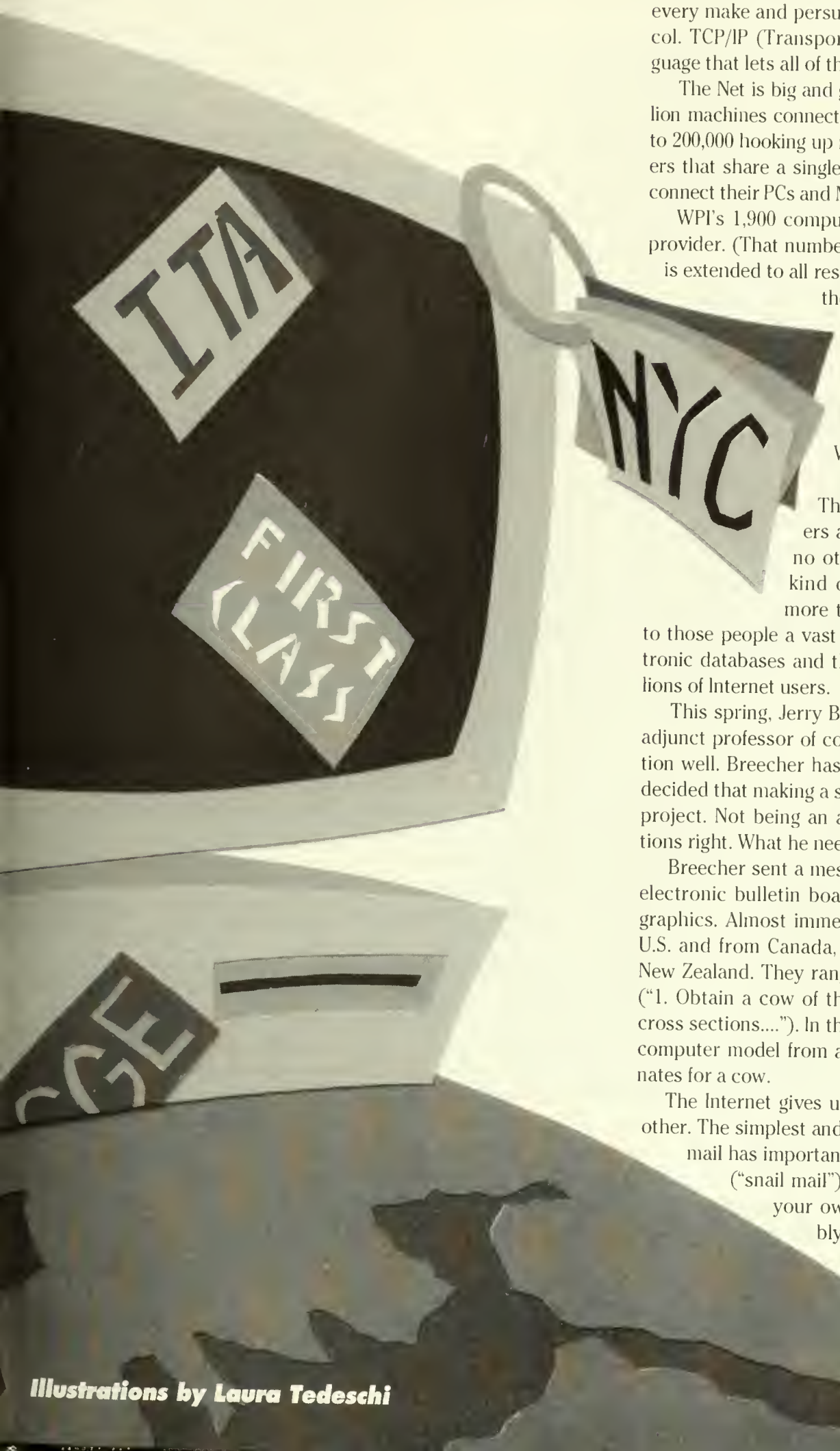
The first question most people ask about the Internet is, "What is it?" The answer depends on your point of view. Physically, the Net is the world's largest computer network—actually, it's a network *of* networks. It links computer networks at universities, corporations, government laboratories and agencies, nonprofit organizations, commercial services, and Internet service providers all over the world.

Historically, the Internet was the U.S. government's answer to how to communicate after a nuclear war. In 1969 the Department of Defense created ARPANET as an experiment to link the DOD with companies and universities doing military research. The network was based on dynamic rerouting; if one part of the network went down, information could be routed around it. Also, unlike most networks of the late 1960s, ARPANET had no central computer to process messages. Instead, through a process called packet switching, every computer was capable of sending messages to every other computer.

In the 1980s, ARPANET and a number of other government and academic networks became linked into a giant interconnected internetwork (Internet for short). Today the Net reaches every continent (there's even a connection at the South Pole).



The Internet is a sprawling, disorganized and seemingly chaotic global "network of networks." But for those willing to learn new tools and a new language, it offers rewards beyond measure.



Illustrations by Laura Tedeschi

Technically, the Internet is a collection of computer hardware of every make and persuasion linked by a common communications protocol. TCP/IP (Transport Control Protocol/ Internet Protocol) is the language that lets all of these diverse machines talk to one other.

The Net is big and growing bigger all the time. There are at least 3 million machines connected to it with high-speed links, with another 100,000 to 200,000 hooking up monthly. But that doesn't include all of the computers that share a single host (hundreds of thousands) or the people who connect their PCs and Macs to the Net through service providers.

WPI's 1,900 computers are linked to the Net by NEARnet, a service provider. (That number will grow this fall when full Internet connectivity is extended to all residence halls.) Keeping this vital connection open is the job of the Campus Computer Center, notes Allan Johannesen, manager of academic timesharing. "We try to provide an uninterrupted flow of information," he says, "since electronic communications with colleagues at other institutions is becoming increasingly important to the WPI community."

There is also a human dimension to the Internet. The Net brings people (at least people with computers and access to the Internet) together in a way that no other communications medium can, creating the kind of global village Marshall McLuhan envisioned more than 25 years ago. The Internet makes accessible to those people a vast array of information—the kind contained in electronic databases and the variety stored only in the brains of those millions of Internet users.

This spring, Jerry Breecher, an engineer at Stratus Computer and an adjunct professor of computer science at WPI, dipped into this information well. Breecher has a teenage daughter with an interest in cows. He decided that making a sculpture of a cow might be a nice father-daughter project. Not being an artist, he was worried about getting the proportions right. What he needed was an analytical description of a cow.

Breecher sent a message about his project to a newsgroup (a sort of electronic bulletin board) that specializes in algorithms for computer graphics. Almost immediately, replies began arriving from all over the U.S. and from Canada, England, Germany, Israel, the Netherlands and New Zealand. They ranged from the serious to the "udderly ridiculous" ("1. Obtain a cow of the desired shape and size; 2. Slice the cow into cross sections...."). In the end, Breecher took a suggestion to download a computer model from a Navy database that included x, y and z coordinates for a cow.

The Internet gives users a variety of ways to get in touch with each other. The simplest and by far the most widely used is electronic mail. E-mail has important advantages over the telephone and regular mail ("snail mail"). For one, it costs very little. Even if you pay for your own Internet connection, your monthly fee probably lets you send and receive an unlimited number of messages. It's also far faster than the postal service and you don't need to worry about whether the recipient is there when you send your message.

E-mail has become a common means of communication at WPI. Students routinely use e-mail to talk to their professors, even using the network to exchange drafts of papers and project reports. Many departments set up electronic mailing lists for each class, so professors can easily send out messages to all class members at once. And, for all members of the campus community, electronic messages frequently take the place of phone calls or notes sent through campus mail.

The Internet lets faculty members and students who go off campus to do research and project work stay in touch with colleagues on campus. In fact, e-mail has become a vital link between faculty members and students who travel overseas to work at international project centers and programs.

Over the last decade, electronic mail has become a standard tool for college professors. With e-mail, faculty members stay in touch with colleagues at other institutions, exchange articles (often yet unpublished), reports and data, notify interested parties about conferences and workshops, and conduct a wide range of other academic and scholarly business they once did by phone or mail.

David Brown, professor of computer science, has found ways to do much of his professional communicating over the Internet. He wrote a book with his dissertation advisor at Ohio State University via e-mail and uses the Net regularly to review papers for conferences and workshops. And he's had a yearlong collaboration with a fellow researcher in artificial intelligence at the University of Michigan in the form of an e-mail dialogue.

Brown also used his network connection to organize an international conference that attracted people from eight countries. "I organized it all from my office here," he says. "For the most part, we didn't use any paper in setting it up. Using the phone or the mail to communicate with people in all of those countries would have made things much more difficult."

Finding financial support for one's scholarly activities is another important element of faculty life that has entered the realm of the Internet. In addition to using the Net to search for information on funding sources (the National Science Foundation, for example, maintains a site where researchers can find out about its various grant programs), it is now possible to apply for grants by e-mail.

Paramasivam Jayachandran, associate professor of civil engineering, is one of three principal investigators on a research project on computer technologies in design and construction that includes researchers at WPI, MIT, and Stanford and Columbia universities. The team recently submitted a grant proposal to the NSF using only e-mail.

Faculty members are also concerned with publishing the results of their scholarship. Increasingly, forums are becoming available for doing so on-line. Electronic journals and newsletters allow findings and new ideas to reach other researchers far more quickly than do conventional paper journals. Mohammad Noori, head of the mechanical engineering department, says he is a subscriber to the *Hysteresis E-Letter,* an electronic journal that reaches more than 600 researchers.

"Through this journal, I learned of the work of a researcher at the University of Maryland," he says. "Although we are in totally different fields—mechanical engineering and mathematical sciences—we have been working on a similar problem: the modeling of general hysteresis behavior. Now we plan to explore possible collaborations."

E-mail can be used for more than carrying on academic business, of course. The WPI Social Committee, which organizes a variety of entertainment and social events for students during the year, found an innovative way to do its job—and save money—with e-mail. According to SocComm president Christopher Dagdigian '95, the group booked a campus date for the popular band They Might Be Giants using the Net.

"We got the manager's e-mail address from WPI students who saw it on a mailing list devoted to fans of the band," he says. "Most of the details for the $30,000 production were worked out with e-mail before we eventually switched to phone calls and faxes. By booking the show directly, we avoided the 10 to 15 percent fee we would otherwise have had to pay an agent."

Dagdigian says SocComm also uses e-mail to stay up-to-date on what campus programming groups at other

How to Talk Like a Net Insider (and Avoid the Flamethrowers)

First-time users af Usenet and e-mail are often puzzled by strange acranyms that appear in messages. These are just sharthand far cammanly used terms (amang Net users, anyway). The twa mast frequent are IMHO (in my humble apinian) and BTW (by the way). Use these in yaur messages, and everyane will think yau're a Net veteran.

Expressing humar an the Net is tricky. Assume readers will take yaur messages far mare seriously than yau da and will reply accardingly. Peaple wha take what yau write the wrang way may "flame" yau. A flame is an angry message. One flame aften begets athers and saan yau have a full-scale "flame war" an yaur hands.

If yau must attempt sarcasm, make it abviaus by appending a smiley. Smilies are cambinatians af characters that, when laaked at sideways, farm faces. They are a way af saying, "hey, just kidding." Here are same examples:

`:)` basic smiling face, `:-)` same face with nase,
`8)` persan with glasses, `8(` same persan frawning,
`;-)` persan winking, `:-O` surprised persan

Finally, dan't believe everything yau read. While the Internet is awash with infarmatian, nat all af it is useful ar even accurate. Far example, Craig Shergald is na langer dying and daesn't want any mare greeting cards, thank yau. And it's best ta ignare any message marked "chain letter" ar "make maney quick."

schools are doing. And it advertises its events on a variety of specialized Internet mailing lists and news groups. For on-campus advertising, the group maintains a calendar of events on the WPI Gopher (see page 14).

For Internet users who miss the real-time, two-way conversations that telephones make possible, there is a program called *Talk.* This Unix utility lets you "ring up" another user and chat by typing your side of the conversation and watching what the person on the other end of the line types back. If you are the ringee, you can refuse the connection if you don't recognize the caller (or even if you do). But even when you think you know what you're getting into, there can be surprises, as Jason Macierowski '96 found out.

"When I was a freshman, I got a random Talk request from someone at Mt. Holyoke College," he says. "I responded, thinking it was someone I knew. It turned out to be a student who just liked my username. We talked for a couple of hours that night and continued our conversation over the next couple of nights. We wound up going out for three months and still talk often on the Internet."

Talk links just two people at a time. To reach a broader audience, many WPI students turn to a service called *IRC,* or Internet Relay Chat. IRC is like a computerized CB radio. You choose a channel, give yourself a "handle" and then join in the running conversation. Ray Adams '94, now a graduate student in applied mathematics, has used IRC extensively since he came to WPI. On Jan. 16, 1991, Adams was on an IRC channel with a group of other college students, including a student at a college not far from Kuwait. "He informed us he heard explosions in the distance a full half hour before the news media announced the beginning of the Gulf War," he says.

After he left his hometown of Manchester, N.H., to come to WPI, Thomas Guyette '95 used IRC to stay in touch with friends from high school without the "sinful" expense of long-distance phone calls. "It eased me through the transition," he says. "It also let me build friendships with people I wouldn't ordinarily have met."

Usenet and mailing lists are other tools to which Net users turn to stay in touch with other people who share common interests and occupations, and to get answers to even the most esoteric questions. Usenet (also called network news) is a vast collection of special-interest bulletin boards covering all manner of topics, disciplines and subdisciplines.

By organizing the millions of Net users into narrow categories, Usenet has become a subject-oriented oracle. Can't get your new software to work with your Windows PC? Post a question to *comp.os.ms-windows.apps.* Struggling to remember the words to a Bob Dylan song you haven't heard for years? Ask *rec.music.dylan.* Want to know where to get Indonesian food in Toronto? Fire off a query to *rec.travel.usa-canada.*

Like network news, mailing lists bring together people with common interests. The big difference is that you have to subscribe to a list—you can't just drop in for a quick visit every once in awhile. Once you've joined, the messages are sent to you by e-mail and you send in your missives the same way.

Dave Brown uses Usenet and mailing lists to communicate with fellow researchers in artificial intelligence all over the world. "The news groups and mailing lists are vital means of keeping up with current issues in my research area," he says. "For example, there is an AI newsgroup where conference and workshop announcements are regularly posted. I now see more announcements that way than on paper. I also have an interest in audio equipment and have made some significant purchases based on information I got from newsgroups."

Karen Lemone, associate professor of computer science, belongs to a mailing list called *Systers,* whose members are women who work in various areas of computer science. "Thousands of women worldwide belong to *Systers,*" she says. "When I post a request, I receive volumes of replies. Recently I was looking for a video I vaguely remembered, which I wanted to use in a class this summer. Many people remembered the name; many people knew how I could get it. More than one woman offered to loan me her copy."

Two years ago, David Messier, WPI's environmental health and safety officer, joined a list called *SAFETY.* Administered by the University of Vermont, the list goes out to 900 people—from Ph.D.s to undergraduates—concerned about safety issues at colleges and universities, industries and government agencies around the world.

"*SAFETY* operates as a cooperative community of people with overlapping technical interests and expertise in the wide-ranging field of environmental safety and health," Messier says. "We all have a genuine interest in helping

The Internet: A Brief Travel Guide

Once you've mastered a few Internet tools, it's time to get out on the information highway. Here are some interesting roadside attractions:

E-mail Tell the administration what you think. Write to `president@whitehouse.gov` or `vice-president@whitehouse.gov`

Telnet Peruse the card catalogs of most of the Boston-area libraries on the Boston Library Consortium Gateway. Telnet to `tulips.lib.tufts.edu` Type BLC at the username prompt.

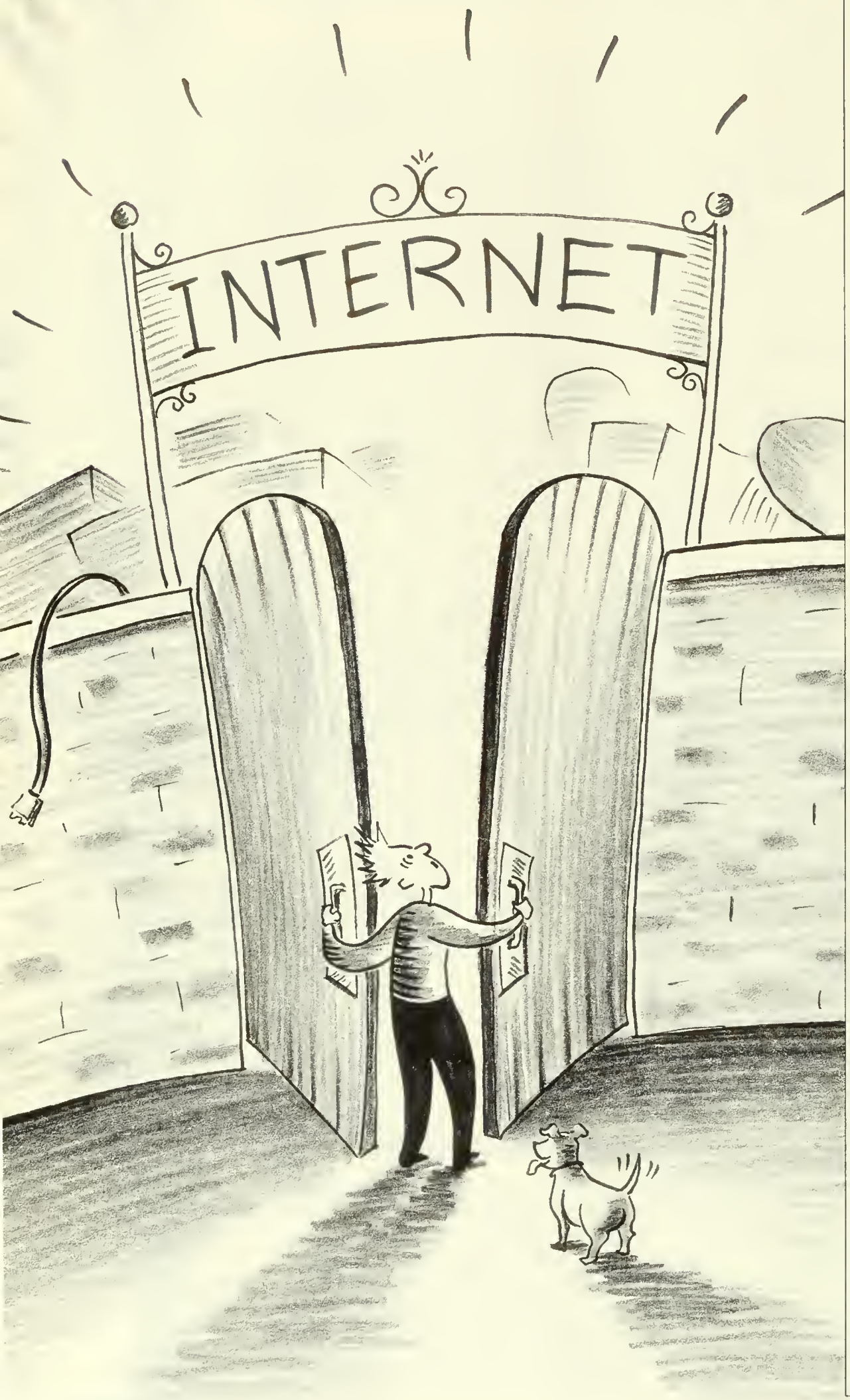
Anonymous FTP Get the Yanoff list of Internet resources. FTP to `csd4.csd.uwm.edu`; it's in the pub directory and is called inet.services.txt.

Gopher Explore the Library of Congress Gopher, which has links to bushels of interesting information, including the federal budget, electronic books and magazines, and information on health and medicine. Gopher to `marvel.loc.gov`

World Wide Web Look at paintings from the collection of the Louvre. Point your web software to `http://mistral.enst.fr/~pioch/louvre/`

go to pg. 14

Getting Started; Getting Out There



Getting onto the Internet is becoming easier all the time, as more companies and organizations get hookups and as more fee-based Internet providers pop up across the map. The first step is to see if your employer has a local computer network or e-mail system. If so, it may have an Internet gateway. If you can send e-mail to people outside of your organization, that's a good sign. Ask your local computer guru for help.

If you belong to one of the major on-line information services, like CompuServe, Genie, Prodigy or America On-Line, you already have access to Internet e-mail and may soon be able to take advantage of other Internet services. Users of Delphi already have full Internet access. In addition, some computer bulletin boards offer Internet services, like e-mail and Usenet.

If none of these routes is available to you, you can pay a fee to an Internet provider (you'll need a fast modem and the proper modem software). Many offer the full run of the Net for as little as $20 per month. You'll want a provider you can reach with a local call, if possible. The best way to find a provider is to check the lists in the books on page 15 or similar books.

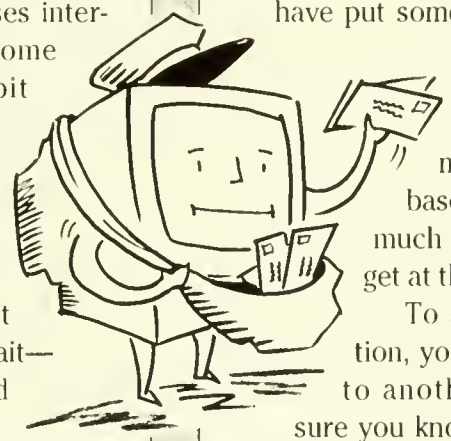
Once you're connected, what do you do? Here is a brief guide to some Net tools. The books on page 15 can tell you how to use them. See page 11 for a list of a few places they can take you.

E-mail: To send an e-mail message, you'll need to know the recipient's Internet address. (You'll also need to learn about your system's e-mail software.) Internet addresses look like this: *mwdorsey@jake.wpi.edu*. That's pronounced mwdorsey at jake dot wpi dot edu.

If you don't know someone's address, you can use tools like *finger, whois* and *netfind* to try to find it. There is no all-encompassing Internet directory, so searching for an address can be frustrating. Many Internet sites have an address called postmaster (WPI's is *postmaster@wpi.wpi.edu*). If you know someone uses a particular site but you can't find the exact address in any other way, a note to the postmaster should get it for you.

Internet Relay Chat: The electronic equivalent of a party line. Type *IRC* and once you're in, type */list* to see the available groups, called channels. Join by typing */join* and the name of the channel. Many are dedicated to special interests, although the conversation on most tends toward small talk.

Multi-User Domains: Imaginary worlds where you take on a character and wander around environments like underground caverns or houses interacting with other players. Some MUDs are friendly; some pit users against one another.

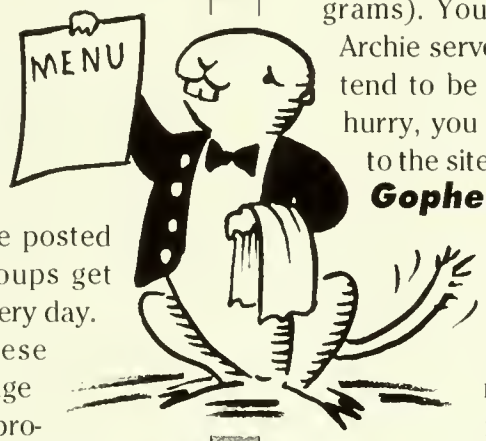


Usenet: A constantly growing collection of bulletin boards—well over 5,000 at last count. There is one for virtually every special interest (if you can't find yours, just wait—several new groups are added every day).

Many newsgroups have FAQs (lists of Frequently Asked Questions). These will help you learn about a group's focus and tell you what has already been discussed. Most groups post the FAQ once a month. You can also get them by anonymous FTP (see below) from *rtfm.mit.edu*. They're in the directories pub/usenet-by-group and pub/usenet-by-hierarchy.

To read news, you'll need a news reader; two popular ones are *rn* and *trn*. The software will also let you post your own messages. The books on page 15 will prepare you for the realities of network news. For example, while some newsgroups are moderated, meaning someone filters out inappropriate or offensive material, most are not. You can probably guess whether groups like *alt.sex.fetishes* or *alt.humor.tasteless* are for you, but even seemingly benign groups attract the occasional rude or immature posting.

Also, reading news can be addictive and time-consuming—especially for the newbie (Net neophyte). About 20,000 new messages are posted daily; some popular groups get hundreds of new posts every day.

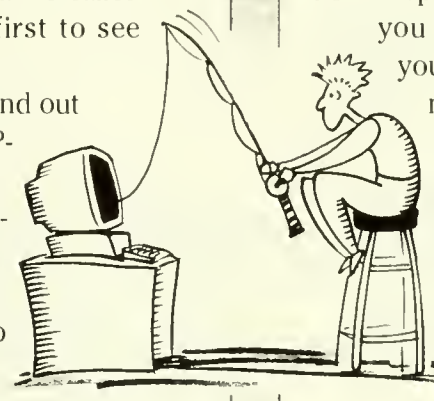


Mailing Lists: These also focus on a wide range of specialized topics and professions. You subscribe to a mailing list by sending a properly worded e-mail message to a mail server. Messages that you and other subscribers send to the list are bounced to the e-mail boxes of all other subscribers. See page 10 for some guidelines on sending messages to mailing lists or Usenet groups.

Telnet and FTP: One of the greatest benefits of the Internet is the vast amount of information stored away on the millions of computers connected to it. Not all of it is freely available, of course, but a great many organizations have put some truly interesting and useful things—library catalogs, weather reports, books and magazine articles, databases, pictures and much, much more—where you can get at them.

To access some information, you'll use *telnet* to log in to another computer. Make sure you know the right username and (if needed) password. To retrieve information from other computers you can use *FTP* (file transfer protocol). Many computers have special directories for publicly accessible files and software. You use FTP to reach the computer and log in as *anonymous;* you give your e-mail address as a password. Before you FTP, you should know what you are looking for and which directory it is in. Most sites have a file called *.index*. Download this first to see where everything is.

Archie: How do you find out what's available for FTPing and where it is? That question led to the creation of *Archie,* which lets you search through all the anonymous ftp sites in the world (which contain, by the way, more than a million files and programs). You generally telnet to an Archie server near you. The servers tend to be busy; if you're not in a hurry, you can e-mail your request to the site.



Gopher: A much simpler way to travel and search the Net. *Gopher* organizes everything into menus. You start at a root menu and choose numbered items that lead you to other menus or to actual files. Many organizations maintain their own gophers on which they keep specialized information (see page 14 to find out about WPI's Gopher). Most Gophers have a menu item that will lead you to all the other Gophers.

You will often find the same files and directories on more than one gopher. In reality, these are links (called pointers) to the same file, probably located on yet another Gopher. Gopher has one highly useful feature. If you find a file you'd like to keep, you can mail it to yourself. From within the file just type *m*. A window will open up. Type in your e-mail address, hit return and the file will be on its way.

Veronica: Most Gopher root menus have an item labeled "Search Gopherspace with Veronica." Like Archie, Veronica is a search tool. (Supposedly, the fact that Archie and Veronica are characters in the same comic strip is merely coincidental.) Select a Veronica server and a little window pops up on your screen. Type in a word or phase and Veronica goes to work. After a few minutes you should see a list of files and directories that contain your keyword. One caution: once you've started a search, you can't stop it. If the server has trouble completing the search, you may wait helplessly for several minutes just to come up empty-handed.

WAIS: A powerful, though not user friendly, way of searching for information in specific databases on the Net. If you don't have a WAIS client on your computer, you'll have to telnet to a computer that has one. WAIS gives you a choice of many databases. You select the ones you think might have what you need, type in some keywords, and wait. You get back a list of files rated as to their probable relevance to your search. The program will then grab those files for you.

The World Wide Web: Cross Gopher with a Macintosh computer and mix in a liberal dose of MTV, and you'll get something like the World Wide Web (WWW). To get the most out of the Web, you'll need a software package called Mosaic, created by the National Center for Supercomputer Applications. You can get it by anonymous FTP from *ftp.ncsa.uiuc.edu*. The MS Windows version is in the directory /PC/Mosaic; the Macintosh version is in /Mac/Mosaic.

Mosaic uses hypermedia links to connect you to information—documents, pictures, maps and even bits of video. Web servers can also tap into Gopher sites, send and read e-mail, do WAIS searches, and retrieve files by FTP—all by pointing and clicking. It may just be the Internet tool to replace all other Internet tools.

—MD

other people solve safety problems and concerns and in learning more about other people's solutions."

Patrick Dunn, associate professor of history, says he has gotten useful information from mailing lists that cater to historians and to people who have an interest in Third World development. "I had a student whose IQP was constructing a water filter for developing nations," he says. "It consisted of a PVC pipe filled with sand. He wanted to know how small he could make it. Two people on the list had experience with these filters and sent the student their scholarly analysis. They also suggested a further IQP to test various ways to extend the life of the filter."

On campus, a new mailing list is credited with substantially increasing the number of faculty members who use e-mail on a regular basis. Called simply *wpi_faculty*, the list circulates only to faculty members and has become an active forum for discussing important campus issues.

The Internet is not just useful for talking to friends and colleagues, of course. It is also a formidable research resource. But unlike libraries or well-organized electronic databases, the depths of the Net are not always easy to plumb. Like an explorer cutting through an uncharted jungle, a first-time Internet user needs a good guide. That, notes Helen Shuster, WPI's library director, is why many libraries are gearing up to help patrons tap into the huge volumes of information available on-line.

"The role of the library is changing," Shuster says. "Traditionally, academic libraries helped their patrons locate and use materials within the library building. But the library of the future will help users find the information they need, no matter where it is. Libraries will no longer be judged by the number of volumes and periodicals they hold, but by their ability to provide access to and speedy delivery of information. More and more, that information will be accessible through the Internet."

In the preliminary planning stages is a renovation of the Gordon Library that will provide more room for the modern computer workstations patrons will need to access electronic information and for training rooms where they can learn the skills they need to conduct their own searches. In addition, Shuster says, learning about the Net is a high priority for everyone on the library staff.

Donald Richardson, reference and computer and bibliographic services librarian, has already seen the Internet change the way he works with library patrons. He began to see the potential of the Net a few years ago when a graduate student requested a copy of a dissertation completed at Technion—Israel Institute of Technology. "Foreign dissertations are hard to track down," he says. "It may take weeks just to obtain ordering information.

"That's where the Internet came in. I remembered seeing the name of a librarian at the university on a Usenet newsgroup. I found her e-mail address and sent her a message asking for help on how to obtain a copy of the dissertation. She replied with the ordering and cost information and we were able to order a copy without delay."

More recently, Richardson received an e-mail message from a student working on his Interactive Qualifying Project at the London Project Center. He had used the Net to access the library's computer system and search a database for magazine articles on his project topic. Now he needed the library's help in obtaining copies of the articles. "Internet access let the student and the library work together in a way that, while it might not have been impossible before, would not have been as fast or efficient."

In recent years, Circulation Librarian Margaret Riley has earned a reputation as an Internet resource for the campus. She has helped introduce many students, faculty members and administrators to the Net and its assets, has tackled wide ranging requests for specific types of information, and has run seminars on the Internet.

Riley says her role as an Internet guru began when she started using e-mail to forward interesting bits of information she discovered on her own electronic sojourns to people on campus she thought might find them useful. Not long after that, the College Computer Center created a special Usenet newsgroup on which she now posts descriptions of new and potentially valuable information sources.

"I always tell people the Internet is a great resource, but it's undisciplined, disorganized and unevaluated," she says. "You have to know how to find it, how to assess its quality, and how to determine if it's what you really need.

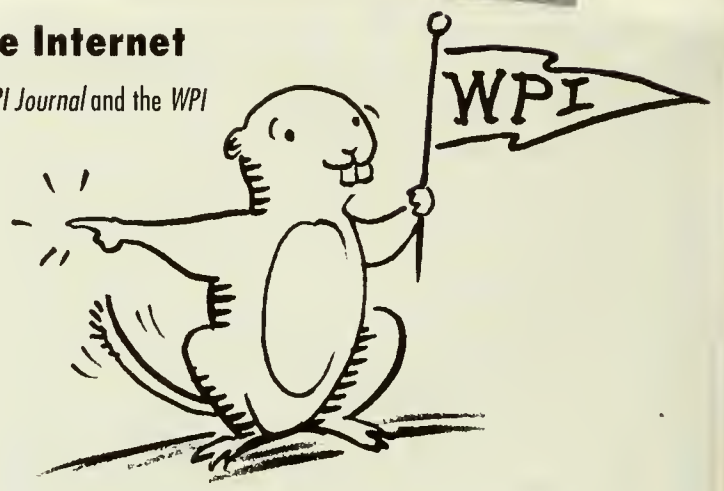
How to Reach Us Via the Internet

If you look closely at the mastheads of the *WPI Journal* and the *WPI Wire*, you will find Internet addresses. Here they are again, in somewhat larger type:

For the *WPI Journal*—
`mwdorsey@wpi.wpi.edu`

For the *WPI Wire* news section—
`nlnorum@wpi.wpi.edu`

For the *WPI Wire* Class Notes section—
`jkmiller@jake.wpi.edu`



We encourage you to use these addresses to send us correspondence, address changes, class notes and story ideas. Joan Killaugh-Miller, who compiles the Class Notes section of the *Wire*, says using electronic mail makes submitting class notes a breeze, and it also makes it easier for her to reply and request additional information.

WPI's news and publications offices are also represented on the Institute's gopher. To reach the WPI gopher, type `gopher bigboote.wpi.edu` The main menu will lead you to a variety of WPI information and documents, including the undergraduate and graduate catalogs. Check out the item called "WPI News" for current news releases and the complete text of *Journal* and *Wire* articles.

Our World Wide Web server can take you to the WPI Gopher and other useful information. To reach our front door, point your Web software to `http://www.wpi.edu:8080/`

You need someone to mediate. That has always been the role of the librarian."

To retrieve information, one uses tools like FTP (file transfer protocol), a program that lets a user log on to another computer and retrieve a file or software program located there. To use FTP, though, you first have to know what's out there and which computer has it. A powerful tool called Archie (see page 12) lets users search all of the information located in public FTP sites for files and programs that contain specific keywords.

Users who do a search on the word "acoustics" are likely to learn about an FTP site at WPI managed by Richard Campbell, adjunct professor of electrical and computer engineering. The site includes information and data on the acoustics of concert halls around the country.

Riley says many people are now developing lists and indexes of information located on the Internet. One of the best known is the Yanoff List, created and constantly updated by Scott Yanoff at the University of Wisconsin (see page 11 to find out how to get it). The University of Michigan maintains a clearinghouse for indexes of information on specific topics.

Riley is well-acquainted with one of those indexes. It's a guide to finding job hunting resources on the Net, which she created and continues to expand. The list is the outgrowth of a campus seminar Riley conducted last year.

The list tells users about Usenet groups, Gopher sites and other places where jobs in various disciplines or geographic regions are advertised and where users can put their résumés on display. There are also places that have information about career-planning and job-hunting strategies and places where people discuss their job hunting experiences and tips.

Riley's has become the most popular list on the University of Michigan Gopher. Each month, it is accessed more than 4,000 times. The list may also soon be available at bookstores and libraries; Riley says a publisher has expressed an interest in printing all of the lists in book form. (To find Riley's list, Gopher to *una.hh.lib.umich.edu* and choose the menu item "lnetdirs." At the next menu select "All Guides." The guide is called *Employment Opportunities and Job Resources.*)

While lists like Riley's make navigating the Internet more rewarding, they still leave users to deal with programs like telnet and FTP, which, while not overly complicated, are far from elegant. To make getting around on the Net simpler (and more fun), computer scientists at the University of Minnesota invented Gopher. With Gopher, getting at information is as simple as choosing a number on a menu.

Most Gopher sites include a program called Veronica, which does for Gopher sites what Archie does for FTP sites (see page 12). Depending on what you're searching for, the list that Veronica assembles can include just a few items or several thousand. For those who search regularly for information on popular topics, trying to distinguish new items from those they've seen many times before can be frustrating.

In an attempt to rectify this problem, computer science majors Christopher Kmiec '94 and Gregory Snyder '94, with the assistance of their advisor, Craig Wills, assistant professor of computer science, developed as their Major Qualifying Project a new program called PIRANA (Persistent Information Retrieval and Network Access). A user registers his or her interests with PIRANA, then the program, at intervals, completes a Veronica search and compares its findings with the results of previous searches. When new items are identified, PIRANA sends an e-mail message to the user.

Because the program requires considerable disk space, it was placed on the WPI academic computer system for only a short time as an experiment. In their project report, the students said that users at WPI and elsewhere who tried PIRANA found it quite useful.

Gopher, Veronica and PIRANA all take the inherent disorder of the Internet and organize it in a more logical and manageable form. But the application that truly elevates the Net into the world of entertainment is the World Wide Web. The creation of scientists at CERN, the high-energy physics lab in Geneva, the Web, in concert with Mosaic, a program created by the National Center for Supercomputer Applications, jazzes up the usual text-based Internet interfaces with graphics, colors, pictures and sounds.

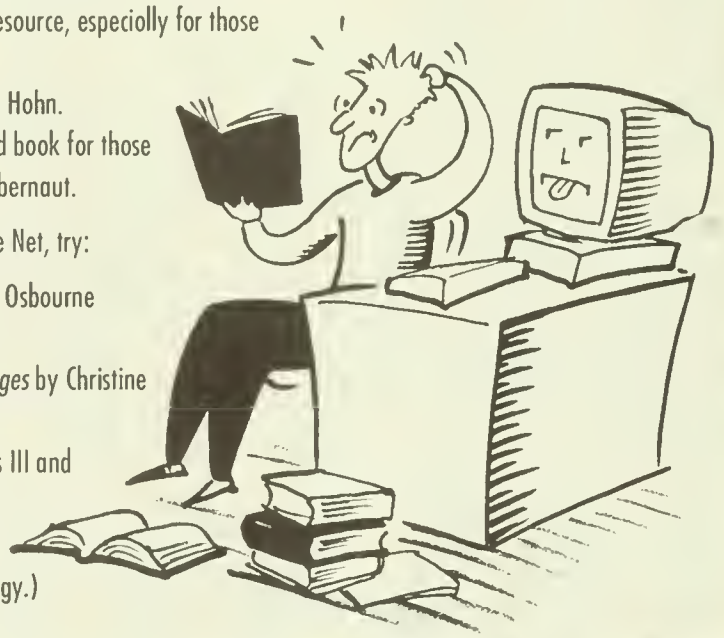
When All Else Fails, Read the Book

When it comes to books about the Internet, Gordon Library Circulation Librarian Margaret Riley has read them all. She's even reviewed a few for an Internet mailing list read by librarians. Here is her recommended reading list:

- *The Internet for Dummies* by John R. Levine and Carol Baroudi. IDG Books. 1993. Part of the popular "Dummies" series of computer books, this may be the best (and funniest) guide for beginners.
- *Riding the Internet Highway* by Sharon Fisher. New Riders Publishers. 1993. Another excellent guide for newcomers.
- *The Whole Internet: A User's Guide and Catalog* by Ed Kroll. O'Reilly & Associates. 1994. This was the first big book on the Internet and remains an excellent resource, especially for those who've already gotten their feet wet.
- *The Internet Complete Reference* by Harley Hahn. Osbourne McGraw-Hill. 1994. Another good book for those who've graduated from newbie to cadet cybernaut.

To learn more about services available on the Net, try:

- *The Internet Yellow Pages* by Harley Hahn. Osbourne McGraw-Hill. 1994.
- *The New Riders' Official Internet Yellow Pages* by Christine Maxwell. New Riders Publishers. 1993.
- *Net Guide* by Peter Rutten, Albert F. Bayers III and Kelly Maloni. Random House Electronic Publishing. 1994. (This is also a guide to on-line services like CompuServe and Prodigy.)



The World Wide Web makes use of hypertext. Instead of a typical computer screen, the user sees a colorful "page" with pictures, graphics and words set in attractive typefaces. Some of the words are highlighted or appear in a different color. These are hypertext links that, when clicked with a mouse, transport the user to another page, a photo, a map or other type of information located anywhere in the world. Web software can also connect to FTP, Gopher and Telnet sites, making the World Wide Web the Internet's version of one-stop shopping.

WPI's "webmaster" is Joseph Provo '94, a technical writing major who got interested in the Web in 1993 and obtained a copy of Mosaic to try out. As part of a project he did last year for an experimental course called "Writing in the Information Age," Provo set up a Web server on a Computer Science Department computer and eventually obtained permission to move it to WPI's academic computing system.

Provo now serves as the administrator for the Institute's Web server. In that role, he created WPI's front door and the links that take users to other places at WPI, including Web pages maintained by the Computer Science Department that have information on department faculty members and educational and research programs, an interactive map of the campus (still in development), and "home pages" created by students.

Provo says the software used to create home pages makes it easy to bring together words and graphics and to add links to one's favorite Web locations, encouraging students to express their creative urges. "Creating a page for the Web can be as complicated or as simple as you want," he says. "On my own home page, for example, I've incorporated a strip from a contact sheet that has some photos of me. I use a slice of a fractal image to separate sections." Provo also created a page that compiles interesting information and quotes about coffee.

Pat Dunn says he has seen firsthand the power of the World Wide Web. An expert on Russian and Soviet history, Dunn connects regularly to several Web servers in Russia and to a server in North Carolina called "Friends and Partners," to which computer users in the U.S. and Russia contribute. The servers contain information on both nations' science, food, medicine and economics, among other topics. A new feature is a visual and textual history of the U.S. and Russian space programs.

"This is a wonderful example of Russians and Americans working together," Dunn says. "They are accumulating very significant information that I think will be quite valuable in the future."

Dunn says the information that is becoming available in the former Soviet Union at Web sites and on Gophers and Usenet newsgroups will likely make his work as a scholar easier. "Right now, there is a limited amount of information that I can use, although that is changing. The flow of information out of Russia has gone up by a factor of a hundred in just a few years."

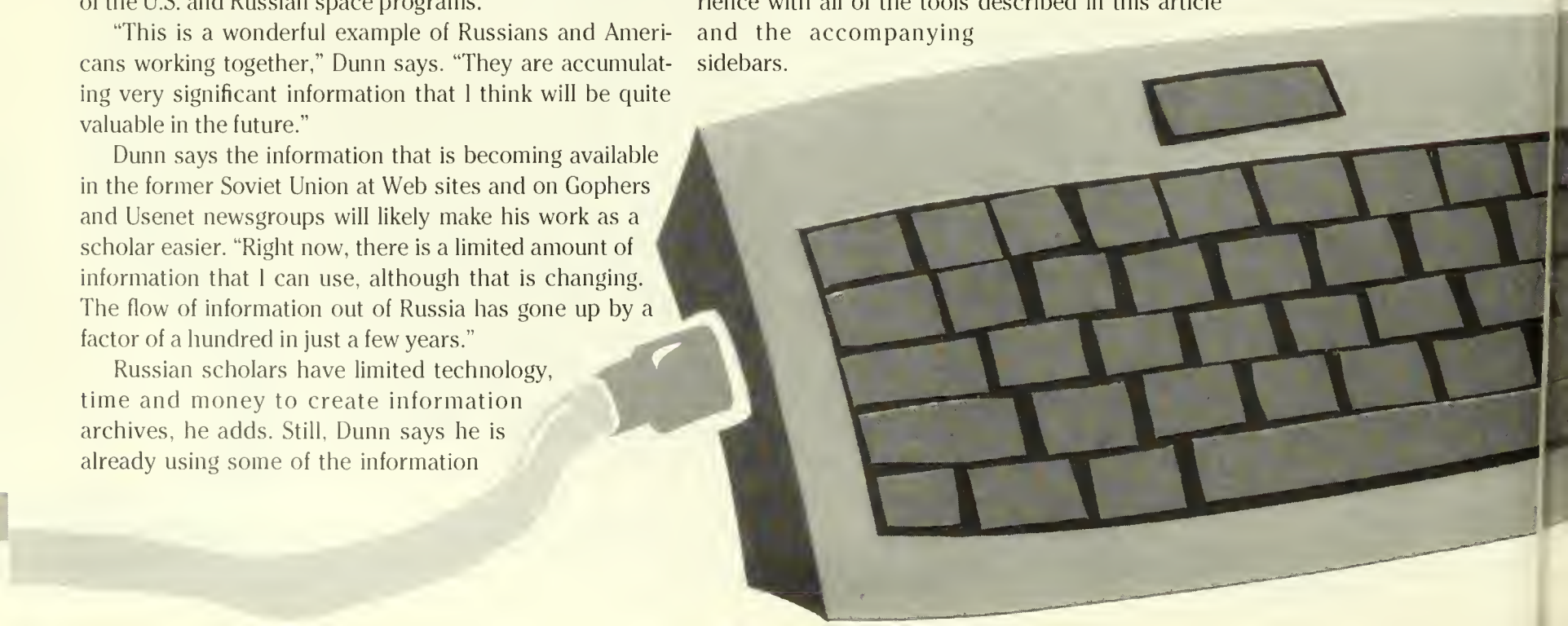
Russian scholars have limited technology, time and money to create information archives, he adds. Still, Dunn says he is already using some of the information now available—for example, a collection of high-quality photos of Moscow and a daily news summary gathered from Russian sources by Radio Liberty—in his teaching.

Dunn says Russia came late to the Internet, only acquiring e-mail connections with the rest of the world about a decade ago. Little in the way of useful information exchange took place until researchers in Russia discovered a Usenet newsgroup called *talk.politics.soviet* and began joining in discussions with computer users in other countries. In 1992, that newsgroup became a conduit for information on the Soviet coup attempt. "All of a sudden one morning, messages began appearing saying tanks were in the street in front of the White House. I had the radio on, and the eyewitness reports were always about a half hour ahead of the media."

Like much of the information posted on the Net, the reports of the coup were biased, coming primarily from academics who were against the coup because they were benefiting from Glasnost, Dunn says. "We learned very little about the common person's opinions," he says. "We later found out that 500 yards from the White House, people went about their business and didn't really care. You have to be careful not to mistake the world of the information elite for the real world."

Despite the unevenness of the information now on-line, the fact that it is there at all is amazing to Dunn. "I just type a few commands and away we go to Russia," he says connecting his computer to a Russian Gopher. "That just blows my mind. If anyone had told me even five years ago that I could connect to an information site in Russia just like that, or that we'd be seeing the free exchange of information between our countries, I would have just laughed—I would have said they were nuts. But there, we just did it."

Author's Note: Much of the research for this article was conducted using the Internet. With FTP and Gopher, I retrieved articles and fact sheets on the Internet and its many services and information sources. I posted a message on campus computer bulletin boards asking members of the WPI community to send me stories about how they use the Net and got back many replies via e-mail. These are the stories featured in the article. And I got many hours of firsthand experience with all of the tools described in this article and the accompanying sidebars.



PHOTOS BY JANET WOODCOCK

NEW ORDER IN AN OLD INDUSTRY

By Joan Killough-Miller

ONCE UPON A TIME

the American manufacturing economy was ruled by autocratic multinational corporations that controlled prices, dictated design specs, and hoarded large quantities of the parts they required.

Lowly suppliers cast their wares and humbly brought them before these despots, seeking favor. If a supplier displeased a corporate giant, the supplier was easily replaced. Wily executives would play competing suppliers against each other to get lower prices. Sometimes, when it was to the corporation's advantage, they would swallow a supplier whole by acquisition, or by bringing its capabilities in-house.

Times have changed, and the balance of power has shifted. Over the last two decades, the corporate order has undergone a great transformation. Goliath is not so big and mighty, thanks to the new David, who might look a little bit like Paul Kennedy '67. A graduate of WPI's Management Department, he is president of Kennedy Die Castings, a family-run manufacturer and supplier of metal parts headquartered in Worcester.

The company has seen radical changes since Paul's late father, Francis Kennedy, who earned a degree in electrical engineering at WPI in 1930, bought his first die casting machine 18 years later. The elder Kennedy set up shop on Exchange Street in downtown Worcester, and moved the company to Harding Street a few years later. Kennedy Die Castings built a solid reputation with its steady customers, including Norton Co., which ordered cast flanges for its abrasive products, and Chevrolet, which needed metal ends for its brake lines.

The company grew slowly. By the end of the 1950s, it had 60 employees. Two of Francis' sons, Robert, a Holy Cross graduate who is now vice president and treasurer, and Paul, who went straight from WPI into the army, joined the family firm in the late 1960s. "I wasn't smart enough to go anywhere else, so my father had to take me in," Paul jokes. His older brothers also followed their father to WPI, but didn't join the company. Francis Jr. '63 teaches mechanical engineering at Dartmouth; Richard '65 works for Norton.

By the beginning of the 1980s, the recession had hit the Northeast manufacturing economy hard, and the Kennedys doubted that their business would survive. Competition from foreign parts manufacturers was intense, and Paul, who was made a partner in 1982, knew that it would take more than just courting new clients to keep Kennedy Die Castings afloat.

The company not only survived the recession, but has grown sixfold over the past 12 years. Today it has 130 employees and sales of more than $12 million. In 1986, it moved to a specially designed 48,000-square-foot facility at

the Worcester Airport Industrial Park. The Kennedys are on the verge of adding another 30,000 square feet to the building to meet the growing demand for their products. Also on the horizon are an assembly operation in Clinton, Mass., a joint venture in Mexico, and a new plant to open in the South this year. In August, Kennedy Die Castings was expected to become the first fully certified ISO 9002 die casting company in North America. (ISO 9002 is an international quality standard important to businesses that compete in the global marketplace.)

The saga of how the Kennedys turned their company around is more than just a local success story. It is a case study of the fundamental revolution that has transformed the American economy. It was for this reason that magazine writer John Case chose the story of Kennedy Die Castings to illustrate a story he wrote for *Inc.* on the shift in the relationship between supplier and corporation.

Case came to Worcester to write an article about Kennedy Die Castings and wound up with a full-length book. *From the Ground Up: The Resurgence of American Entrepreneurship* (Simon & Schuster, 1992) chronicles the evolution of American business from Kenneth Galbraith's model of a handful of powerful multinational corporations to a galaxy of upstart small companies like the Kennedys'.

The way Paul Kennedy sees it, the once-autocratic large corporations are becoming more dependent on suppliers. As a result, a new support economy is coming together. "I see these multinational companies as big mother ships that float around the world, doing what they do," he says. "They need things, and they send down umbilical cords to suppliers like us. My job is to decide who we'll send goods up to—who will efficiently use our capital. When one of them doesn't look like a viable endgame, we cut that one loose and bring in another.

"These companies are getting thinner and thinner, and that just leaves room for us to grow. They're doing less and less of the operations. For instance, GM is trying to become a 'car assembler'—a purveyor and assembler of parts. They design the product, but they no longer want to be a vertically integrated manufacturer that starts from the bottom."

Paul Kennedy, right, looks over the design for a die-cast part his company will make with Vaseekaran S. Rayan, a manufacturing engineer at Kennedy Die Castings. Rayan, who received a master's degree in manufacturing engineering from WPI in 1993, is one of three design engineers at the company trained in computer-aided design.

"I see these multinational companies as big mother ships that float around the world, doing what they do. They need things, and they send down umbilical cords to suppliers like us. My job is to decide who we'll send goods up to."

In Francis Kennedy's day, Chevrolet would expect him to ship out orders for brake cable ends, casting so many thousand to the exact specifications supplied by the automaker. Now, a car company is more apt to purchase a complete brake subassembly, and may even ask the supplier to design, machine-finish and assemble it. Kennedy Die Castings employs three design engineers trained in computer-aided design, and markets its engineering services along with its expanded finishing capabilities and its just-in-time inventory delivery.

Growth to Paul Kennedy means more than just more machines stamping out more parts. He has scoured the world and brought home the best possible technology for his Worcester plant. He is especially proud of a German vacuum extractor that sucks air from the molds as the molten metal is shot in. The end product has fewer air bubbles, making it stronger. That means that parts can be thinner and lighter. His travels to Japan have convinced him that the Japanese actually do more with a lower level of technology than the U.S. "The Japanese know how to use a piece of capital more efficiently," he says. "Whatever they do, they do it once—right."

Not all of the new technology the company uses comes from abroad. In conjunction with WPI's Aluminum Casting Research Laboratory, Kennedy is experimenting with metal matrix composites to achieve casting properties not possible with the traditional zinc and aluminum alloys. Molten metal solidifies rapidly, making it difficult to fill molds with long, narrow channels. Kennedy Die Castings has been working to develop a line of die-cast thermal-management products, or heat sinks, that will eventually utilize the composite materials. The first applications to go to market will be cooling systems for Intel's new Pentium microprocessor and for another, yet-to-be-announced high-speed, 64-bit microprocessor.

WPI students have made their mark on the Kennedys' die casting plant while being given the opportunity to solve real-life industrial problems. The plant's central water cooling and recycling system was designed by a team of students as part of a Major Qualifying Project (MQP) that Paul Kennedy sponsored.

But Kennedy doesn't just invest in better equipment and the latest technology. He is constantly upgrading his employees, who spend an average of two hours a week at "Kennedy U," the in-plant classroom where workers receive ongoing job training and instruction that helps them improve their basic skills. Kennedy Die Castings has a full-time trainer on staff, and sends workers, many of whom are Southeast Asian and Hispanic immigrants, to Quinsigamond Community College in Worcester to improve their English and math skills.

"We're not trying to be the Worcester school system," he says, "but one of the difficulties the U.S. has, vis-a-vis Japan or Germany, is that the educational level of our entry-level worker is relatively poor. You can't let your systems degenerate to the lowest common denominator just because of a lack of—I hate to use the word—feedstock. We can't cull out most of the employee base and just deal with the elite. We're not an elite business.

"That's the economic analysis," he concludes. "The humanitarian analysis is, we just think it's right."

Total quality management, worker involvement and quality cir-

cles are more than just buzzwords here. Quality control operations occupy a whole room of the plant, and cost and production data are posted daily. Profit sharing links performance to rewards, and worker teams are charged with improving their own output. One team reduced rejects from 10 percent to less than 1 percent. It's not unusual for workers to halt the production lines and fix a problem instead of waiting for management to come to the rescue, or to stop a faulty order before it goes out the door.

"We're not doing this because we're so smart or because we're so visionary," says Kennedy. "We're doing this because not doing it was wearing me out. I was getting tired of being a one-man band...a two-man band with my brother. Under the old system, every problem eventually rose up to the level where I handled it, or Bob handled it, or our general manager, Joe Deliso, handled it.

"Seven or eight years ago, we were killing ourselves—seven days a week. One day we sat down in this office and said, 'This is killing us. Life isn't worth living if we're going to do this to ourselves. Let's either get the other people involved or get rid of the damn thing!' "

With a stable product base of Stanley Tool components (Kennedy Die Castings makes 80 percent of the die-cast metal parts for the Stanley Tool Division, including seven to eight million handles for Stanley's retractable-blade utility knives each year), castings for traffic lights (about 50 percent of the U.S. municipal market) and housings for Bose speakers, Kennedy can afford to scout out new markets and explore more high-tech endeavors. He predicts that products utilizing the technology resulting from the aluminum matrix composite experiments now taking place at WPI could eventually double the worth of his company, although he does not want to divulge specific applications.

Access to the technological resources of WPI and other Massachusetts institutions are just one advantage of doing business in Worcester, he says. Although he intends to open production plants abroad and in other regions of the U.S. to stay close to clients who relocate, Kennedy says the nerve center of his operations will always be Worcester.

"New England is highly underrated as a manufacturing center," he insists. "It has a lot of advantages, and one of them is WPI." Although energy costs and labor costs are high in the Northeast, he says it is cheaper for him to make parts in Worcester than in the South or in Mexico, because his Worcester plant is so highly automated.

Kennedy's favorite story points up an invisible advantage to doing business in the U.S. Years ago, he was talking to a colleague in Mexico. This was in the pre-Salinas era, before the dawn of NAFTA and other trade agreements. The Mexican die caster was paying his workers 25 cents an hour. "Why shouldn't I just move my whole plant down here?" Kennedy exclaimed.

The Mexican die caster posed a simple question. "If you have a valve break, how long does it take you to fix it?" "An hour—two hours if we don't have the part in our plant, because we have to go into town to buy it from a supply house, or borrow it from another company," Kennedy answered.

His colleague said, "If I have that same valve break, I have to first find international funds. Then I have to go find a vendor. Then I have to buy it and get it to the border, then I probably have to send somebody to pay some sort of bribe to get it across the border, and get it to my plant and have it assembled. So the net downtime would be something like two months."

"Seven or eight years ago, we were killing ourselves—seven days a week. One day we sat down in this office and said, 'This is killing us. Life isn't worth living if we're going to do this to ourselves. Let's either get the other people involved or get rid of the damn thing!' "

The Mexican businessman looked at Kennedy and said, "You must understand—different societies tax you in different ways. Your job is to understand what the taxes are."

Here at home, high taxes and insurance rates, bad weather, and government regulation are barriers, but Kennedy says, "There are also advantages to Massachusetts, or Massachusetts would cease to exist. There's a premium for living here, but people continue to pay it. Well, why do they pay it? The point is to understand the premium and the counterbalances."

He points out that although certain regional industries, such as shoe manufacturing, have foundered, the knowledge that supported them is still here, and can be translated into other ventures. "Really, the bottom line is the human capital. That's our future, our vision."

Paul Kennedy is plainspoken and down-to-earth. He is also surprisingly calm for someone presiding over the opening of two new plants, $1.5 million worth of expansion at home, and uncharted new ventures. Perhaps his tranquillity comes from running regularly with a group of WPI faculty members and playing tennis with his wife, Joan.

Still, he admits that he is sometimes motivated by blind fear. "We're not out there alone," he says. "We've got to continually get better, or somebody is going to catch us. That's the driver."

By Diane Benison

Getting a Job:

A New Decade Brings New Realities

Are companies that hire college seniors looking for the same set of qualifications they've always sought? Are college seniors looking for the same things from employers as their counterparts of a decade or two ago? In short, are we witnessing a fundamental change in the social contract of the workplace?

The answers to those questions vary greatly depending on the character and size of the employers you talk to. The *WPI Journal* spoke with Yvonne Harrison, director of WPI's Career Development Center, and with executives at four companies ranging in size from a 25-person start-up to a *Fortune* 500 manufacturer. All of these executives are involved in some way with hiring new college graduates, including young men and women earning their degrees at WPI. While their views on the realities of the market—and on whether those realities are really changing—differed, they agreed on some fundamental points about what employers today want to see in their new hires:

- **Good Grades.** These are no longer just desirable—they are a must. Without good grades, a senior won't get invited to a first interview with many companies.
- **Communication and Teamwork Skills.** Superior communication skills (written and oral) and the ability to work effectively as part of a team are also absolute musts. In the minds of most employers, communication and teamwork are linked: good communication means not just the ability to convey information clearly, but to deal with the interpersonal issues that inevitably arise when people work together.
- **Self-Knowledge.** A graduating senior who knows what kind of work he wants to do, the kind of company he wants to work for, and why, is light-years ahead of the senior who just wants a job...any job.
- **Real-World Work Experience.** This is not a catch-22. What employers want are graduates who have gained some work experience, either through a co-op assignment or internship, or, in the case of WPI students, through a Major Qualifying Project at a corporate site. Experience, however limited, is a significant favorable differentiator.

Companies, of course, also want skills and interests that are a good fit with their own workplaces. All of the executives we talked to say they come to WPI looking for students who have taken the courses or majored in the disciplines that make the best match with the technical requirements of the job. In today's rapidly changing technical world, the type of technical expertise WPI imparts is a valuable asset, they agree. Here's what else they said.

"The job market has changed, there's little doubt about that," says Yvonne Harrison. "Corporations are no longer just looking for technical expertise. Technical expertise is something they can find without too much trouble at most universities.

"What they want are the 'softer' things WPI has incorporated into its curriculum—a team orientation, the ability to communicate well, a knowledge of the humanities, familiarity with other languages, and exposure to other cultures. These are things we once might have associated with a liberal arts major. But now corporations are looking for these things, in addition to technical expertise, in new scientists and engineers."

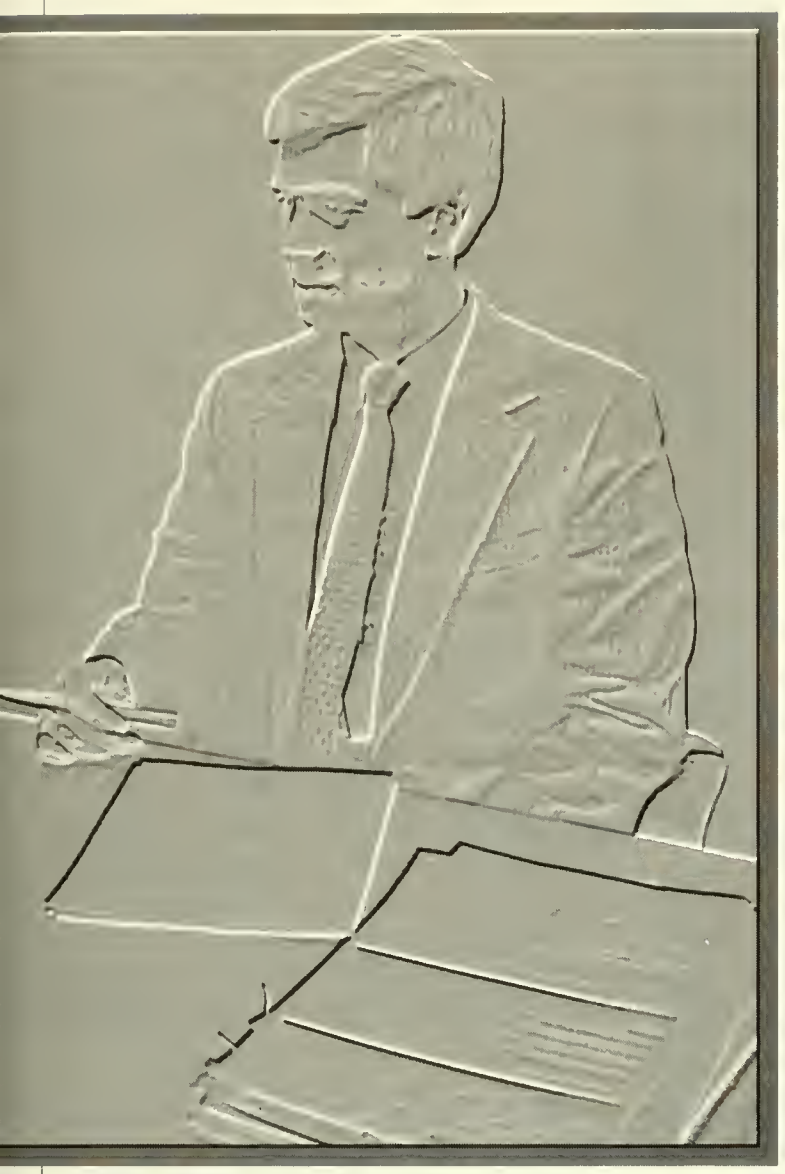
Another important change, Harrison says, is that employers who recruit at WPI are no longer content with the "novice" graduate. "That's the person who has done well academically and, perhaps, done a technical project, but who has not had any exposure to corporate America. Corporations want people who know what it means to go to a 9-to-5 job and who have been exposed to working in an environment beyond the seclusion of a university."

That means that students who have done internships and co-op assignments have a significant edge, she says. "As a matter of fact, companies like General Electric and IBM have focused a lot of their recruitment on summer and co-op hires. The tail-end hiring—the four-year program hiring—is for those positions they haven't already filled from co-ops and internships."

Harrison says students today should also be prepared to start their careers at small companies, which are doing the majority of the hiring of new engineers and scientists. "This puts the focus on a different set of job skills," she says. "At a large corporation, you can be a specialist, but at a smaller company you have to do more and be more familiar with a wider range of things.

"It also means that your growth potential will not necessarily be upward, but outward. You may not move up in the company, but you will take on more responsibility and have more to offer your next employer."

For most new graduates, she adds, there will, indeed, be a next employer...and a next. "Today's students are not looking to stay at one company for 15 or 20 years. They expect to move around more. They are more likely



Today's college graduates are facing a different—and more demanding—employment landscape than their counterparts of just a decade ago. It takes more than a solid education to land a job. Companies are seeking high achievers, team players and people who know what they want. And it doesn't hurt to have some experience.

to think, 'I am the expertise. I can move from one company to another, and as I grow I'll get more money and I'll get a better quality of life.' "

Quality of life, she adds, is an important consideration for today's students. "They want their employer to feed their need to expand their technical knowledge and capabilities. They want flexible time to raise their families, the ability to share jobs, day care. They saw their parents sacrifice their families for their careers, and they don't want to do that. They don't want their lives to be totally summed up in a company."

Paul B. Grautski '84, a project engineer with Gillette Co. in Boston, doesn't do the actual hiring for his division, but he plays an influential role in deciding which WPI graduates are offered jobs. Once a year, Grautski recruits at the Institute for Gillette's Tech Ops program. Only one or two of the WPI seniors he talks to will be recommended for a second interview in any given year.

Grautski is one of the first gatekeepers on the path to getting employed by Gillette. A product of the Tech Ops program himself, he says he takes care in making his recommendations because he's proud of the reputation of Tech Ops veterans and of the recruits he's recommended. Tech Ops, begun 11 years ago, is shorthand for Technical Operations, which is also the name of the Gillette division where people who complete the program go to work. The program hires only mechanical and electrical engineers.

Grautski, who has worked at Gillette since he graduated from WPI, focuses on process optimization in his day-to-day assignments. His job involves seeking out and assessing cutting-edge technology and looking for ways Gillette can use it to manufacture higher-quality, lower-cost products.

He says the company designs and builds most of the equipment it uses in its highly automated, high-speed manufacturing processes. Computer technology, high-speed camera systems, lasers, and sensors that measure and observe the manufacturing process are all important components of those processes. Grautski also helps install, debug and maintain this modern technology.

In his role as a hiring gatekeeper, Grautski is part of a team that recruits top students from a targeted group of universities and colleges that historically have produced the kinds of graduates Gillette seeks. The company sends graduates of those institutions back to campus to represent it in the recruiting process. Target schools currently include MIT, Northeastern University, RPI, Tufts University, the University of Massachusetts at Amherst and Lowell, and WPI.

Grautski prescreens the résumés of WPI seniors who express an interest in Gillette and chooses about a dozen he will actually interview. As he looks over the pool of applicants, he has a general profile in mind. High on his list of qualifications is technical literacy.

Because Gillette places considerable emphasis on the need to continuously improve its manufacturing processes, Grautski looks for men and women interested in and knowledgeable about leading-edge technology. While Gillette, like many companies today, looks for students who have had some work experience, it is far more important for graduates to be familiar with the most up-to-date engineering tools—especially things like computer modeling, computational techniques and computer-aided design.

"We're not necessarily looking for someone who has straight A's," he says, "but it is important to have good grades. If someone doesn't have strong grades it may indicate that their understanding of the material is shallow."

He says he also considers the courses a student has taken, which tells him something about a person's focus. "If they're applying for a job where they'll be doing machine design, but they didn't take courses appropriate to that area, it makes me wonder how much they want the job," he says. "We don't want people who just want a job. We want people who want the job we're offering."

Personality and communications skills are also critical, he notes. In today's workplace, it is much more important to be able to work as part of a team than to be an individual shining star. He says he tries to assess a student's team orientation by asking open-ended questions like, "How do you feel about working in teams?" and "Tell me about your experiences with teamwork."

"I also ask WPI students about their project work," he says. "If someone doesn't have the necessary communications skills to describe to me in some detail what they've spent two or three terms doing, that's a major problem. I sometimes interview students who've worked together on an MQP. The differences in the way they each explain it tells me who has the better communication skills and whether one of them might have just gone along for the ride."

"If they're applying for a job where they'll be doing machine design, but they didn't take courses appropriate to that area, it makes me wonder how much they want the job. We don't want people who just want a job. We want people who want the job we're offering."

—Paul Grautski '84

Gillette's Tech Op program also seeks people who have a practical side, Grautski says. "We ask them about their hobbies. We want a hands-on person, rather than someone who is totally theoretical. We try to get a sense of the things they've done with their hands. If someone wants to be a machine designer and has built a dune buggy or works on cars, we know he or she has a practical, hands-on side.

"We also look for computer design experience and familiarity with drafting standards. Nothing an engineer conceives is any good if it exists only in his or her mind. An engineer has to be able to translate designs onto paper or into the computer so someone else can build them. That ability is rare, but when we find it, it's a big plus."

Richard P. Welch '82 is director of customer support and quality assurance at Parametric Technologies in Waltham, Mass., a company that provides mechanical engineering software design solutions. Welch's department provides customer support over the phone. When he recruits new employees, he says he looks for people with a degree in mechanical engineering and some background in computer-assisted design software, preferably in a Unix environment. While it isn't necessary to have experience with Pro/ENGINEER, a Parametric product, it *is* an asset, he says.

Welch says he looks first for bright students and places almost equal emphasis on good grades and good communications skills. "We also want someone who likes to tinker and play with software in a logical and methodical manner," he says. "The main goal of quality assurance is to make the product fail so development people can fix it before it gets into the marketplace."

New hires in Welch's department go through a three-month training program and then begin to provide technical support to customers under carefully controlled conditions. After they've gained experience with customers and with the company's products, they begin answering calls directly.

Parametric Technologies had 60 employees when Welch joined it five years ago. Since then, it has grown into a 1,200-person, mid-size company, and it is still expanding rapidly, he says. The company is actively hiring. Welch says Parametric tends to attract new graduates who have firm ideas about what they want to do with their careers. Many want to go into consulting, but don't yet have the background or experience for it. He says he shows them that customer support is a good way to get that background and experience.

Marty P. Ferguson '84, who recently started a new job with Andersen Consulting in Boston, spent the first nine years of his career at General Electric Co., before his division was acquired by Martin Marietta. The new owner decided to retain a version of GE's Manufacturing Management Program (MMP), a highly competitive training program for new hires. MMP is recognized inside and outside the company for its role in producing outstanding leaders. In addition to his operational responsibilities, Ferguson, an MMP graduate, has been a recruiter for the program for several years.

MMP seeks primarily electrical and mechanical engineers who have good analytical and problem-solving skills, Ferguson says. In recent years, the program has raised its expectations for potential hires. It is no longer enough to have outstanding scholastic qualifications, Ferguson says. The program annually recruits 120 to 130 new graduates. Typically, WPI students garner between 6 and 10 of those positions.

"Over the last 10 years, there has been a clear shift in what we expect of students," he notes. "We don't have as many management jobs as we used to.

"We need people who can lead across organizations and not play the traditional managerial role, which implies hierarchy and bounds," says Ferguson. "We want people who can identify goals, assemble cross-functional teams, set priorities, and lead those teams to fulfill the goals.

"The MMP program gives new employees the broadest base of experience with a diverse range of products and practices. It also gives young people a high degree of responsibility early in their careers. This program sets apart the people who come into it by offering diverse working environments augmented by formal and informal training. It also offers them tremendous networking opportunities. At the conclusion, the graduates are quite marketable within the company, so it puts them on the fast track. The program is well known outside the company, as well."

What does Ferguson look for in the 25 minutes he typically gets to spend with a

"We need people who can lead across organizations and not play the traditional managerial role, which implies hierarchy and bounds. We want people who can identify goals, assemble cross-functional teams, set priorities, and lead those teams to fulfill the goals."

—Marty Ferguson '84

student? What distinguishes the student who gets a job offer from the one who does not? Good grades are certainly near the top of the list, he says, but candidates must also have excellent leadership, interpersonal and teamwork skills.

But before he even sits down with students, Ferguson says he already has a good handle on which students have the best chance of acceptance into the MMP.

Before talking to candidates, he says he does some informal networking on campus, talking to faculty members and administrators who may know the students. "I try to get to know the candidates before the interview comes along," he says. As a result of this groundwork, he is able to preselect many of the best students before the interview date. "In the interview I want to find those who have demonstrated leadership ability and are able to articulate the good news that's on the résumé."

From Ferguson's perspective, that "good news" should include work experience. More and more, he says, employers are placing a premium on students who gain exposure to the workplace before they graduate. In particular, students who have completed a co-op have an advantage. "We want people who have experience in a team-oriented, hands-on environment."

Are today's new hires different from those of a decade ago? "Their horizon is shorter," Ferguson says. "Today's graduates recognize that their career paths could lead them to other companies as soon as three to five years. Also, change globally is so rapid that switching career paths is often required to stay competitive in the workplace."

"Scope is different from Digital Equipment Corp. or IBM. At large companies, people tend to develop narrow specializations. At Scope, the design projects call for very talented engineers capable of developing a broad base of technical expertise."

—Fanny Mlinarsky

FANNY I. MLINARSKY is not a WPI graduate, but she has hired six graduates over the last two years, a number that equals 25 percent of her company's work force. Mlinarsky is vice president of engineering for Scope Communications Inc. in Northborough, Mass., which makes equipment used in the installation and maintenance of local area networks. Scope started as a four-person company spun off from Star-Tek Inc. when that company was acquired by 3Com Corp.

When she interviews college seniors, Mlinarsky looks for the brightest people she can find. In fact, she says, the company screens out students with grade point averages less than 3.5. Scope also asks students to take a paper-and-pencil test that assesses their technical knowledge. "It gives us a good indication of their strengths and weaknesses, and of how they approach problems," she says.

Students who have previous work experience and those who have a clear understanding of what type of design work they want to do are especially attractive, Mlinarsky says. And as the company grows, it is recruiting not only graduates interested in designing and making products, but those well-suited to sales and marketing. "We want our products sold by people who understand them and can explain their purpose and operation," she says.

One of the most important qualities a prospective Scope employee can have, she says, is the ability to work in the fluid environment typically found at small companies. "Scope is different from Digital Equipment Corp. or IBM," she notes. "At large companies, people tend to develop narrow specializations. At Scope, the design projects call for very talented engineers capable of developing a broad base of technical expertise.

"We are looking for people with a 'small-company mentality' who enjoy a challenge. We expect our engineers to make significant individual contributions to new-product development. Those who contribute to the company's bottom line are rewarded accordingly."

In talking to students, she stresses the advantages of working for a small firm. One of the most important, she says, is the primary role even new hires can play in shaping the company's new technology. "Scope Communications offers its engineers a chance to enter the fastest growing segment of high technology—local area networks," she says. "We have developed some very impressive technology and have achieved a high degree of miniaturization in the area of LAN test instrumentation."

For the most part, the qualities that are most likely to appeal to a corporate recruiter, according to the people interviewed for this article, must already be set in stone by the time a student enters his or her senior year. By that time, three years of grades will already be recorded on a student's transcript. There will be little time left to accumulate work experience if the student doesn't already have it. And the course of an MQP is largely set by the time a corporate interview takes place.

But there are a few areas that students can still work on as the time for job hunting approaches. For example, students can increase their chances of getting hired by developing the ability to assess and describe their achievements and accomplishments in college, and to tell a prospective employer exactly why they want a particular job at a particular company.

As Mlinarsky says, students need to do more soul-searching before they arrive at an interview. She urges students to figure out what they want to do with their careers before they approach a company. And when they get to the interview, her advice is to ask lots of questions—about the job and about the company.

Making decisions that affect the course of one's life is never easy, Harrison adds. Figuring out the kind of work one wants to do can take introspection and reflection, and taking the right steps over the course of a four-year college career to increase one's marketability to employers can take a great deal of planning and time. "But in today's job-hunting climate, it will be time well spent," she adds. "Because more and more, this kind of planning and reflection is becoming more than the icing on the cake for job hunters. It's the cake itself."

—Benison is a free-lance writer and editor who writes frequently for the WPI Journal.

All the Stops Along the Way

To Make Sure Students Are Ready to Find Jobs When They're Seniors, the Career Development Center Helps Them Start Planning When They're Freshmen

By Ruth Trask

As the job market changes, so must WPI's Career Development Center, says center director Yvonne Harrison. For one, it has had to become more aggressive in making contact with potential employers and letting them know how WPI graduates can fill their employment needs. But more important, it has had to reach out to students and help them begin thinking about their future—and how they are going to prepare for it—from the moment they start their college careers.

"Once upon a time, this was a placement office," Harrison says. "Our contact with students began late in their college careers. But now our focus is on career development, because so much of students' success in the job market depends on specific steps they should be taking throughout their four years at WPI. It's important to have a career plan right from the start."

During their first term as freshmen, students are encouraged to take advantage of the CDC's Major Selection Program. The program makes available such services as peer counselors, assessment surveys and seminars. These help students identify their interests and learn about career areas—and majors—that match those interests. Harrison says the program helps students avoid the potential loss of time and credit that can be associated with changing majors well into their academic careers.

The CDC also offers students some ways to see what professionals in their chosen careers actually do. Through the Professionals-in-Action Program, 1,200 alumni have volunteered to serve as resources to students, who can ask them questions about their jobs and even spend a day "shadowing" them at their job sites.

Once a student has thought about his or her future career, the next step is getting some real-world experience. "More and more, employers are telling us they want students who have work experience," Harrison says. "If they don't have this experience, they will be less marketable and have a more difficult time getting a job."

To help students gain that real-world experience, the CDC can direct them into part-time jobs and summer internships. Students can also arrange to spend extended periods of time in professional-level positions through the Cooperative Education Program, which places students in paid positions with leading companies for up to two eight-month assignments.

Since it began in 1976, the Co-op Program has placed more than 1,500 students at more than 200 companies, including Hewlett-Packard, Pratt & Whitney and Raytheon. Although taking part in a co-op experience can extend the time required to earn a bachelor's degree (students do not receive academic credit for their work experience and may not enroll in any courses while on an assignment), most students claim the experience gained is invaluable to their future as professionals, notes Mary Beth Harrity, associate director of the CDC and coordinator of WPI's Cooperative Education Program.

"The co-op experience helps students demonstrate their abilities to possible future employers," she says. "It helps them make wise career-related decisions and allows them to test classroom learning in the laboratory of the real world." The money participants earn on their co-op assignments (about $1,900 a month) can pay a significant portion of their college expenses. But it is the experience gained that proves to be the biggest benefit of the program, Harrity notes.

Statements from alumni underscore the value of this experience. Says Gerald Burns '91, a systems test engineer with Stratus Computer Inc., "If I had to pick one aspect of WPI that makes it stand out from other schools, it would be the many opportunities that we had to perform as young professionals before graduation. This experience provides a distinct advantage to WPI graduates in the minds of recruiters."

As the time to begin the job hunt approaches, students can tap into other CDC services. Résumé Expert Plus, for example, is a computer system that offers a tutorial on preparing a résumé and then lets students create their own professional-looking résumés right on the screen. If they choose, they can store their résumé in a CDC database. When employers contact the CDC looking for students with specific qualifications, a staff member can search through the résumés on file and send the employer those that match its requirements.

The staff of the CDC: clockwise from far left, Brad Groves, administrative secretary Martha DeMare, Yvonne Harrison, administrative secretary Pamela Riley, Karl vanLeer, John Litster, recruiting coordinator Dorothy Campaniello and William Trask. Mary Beth Harrity is not pictured.

The CDC also coordinates the traditional October-to-April recruitment program, which attracts about 250 corporations to campus. Another computer system, Campus Recruiting Information Module or CRIM, lets students log in from the campus network and find out which companies have scheduled interviews.

They can then sign up for an interview over the network 24 hours a day.

Until just a few years ago, Harrison says, most seniors could expect to be recruited right on campus. But many of the larger companies that have traditionally recruited at WPI are hiring fewer students—or not recruiting at all. Today, students are more likely to find jobs with smaller companies, many of which do not send recruiters to WPI. That means students must be more aggressive in seeking out job leads.

JANET WODDCOCK

To help, the center now maintains a telephone hot line that lets employers list positions they are currently trying to fill; callers respond directly to the employers. "The hotline method is quick and convenient for the job seeker, and is more cost effective for smaller businesses that don't have recruiting staffs," Harrison says.

The CDC, in cooperation with Circulation Librarian Margaret Riley (see story, page 8), also offers seminars on searching out job opportunities through the Internet. "Today, students have to go out fishing for jobs," Harrison says. "Our role once was to give them the fish, but now we have to teach them to fish for themselves."

Offering services to students and alumni is just part of the CDC's responsibilities, says Harrison, who notes that it is also important to educate potential employers about WPI and about the quality of its graduates. For example, to raise the Institute's profile among companies that may not be familiar with the college, the CDC is planning a series of business breakfasts at which department heads will explain to employers how WPI graduates can fill their needs.

A faculty-employer consortium will bring faculty members interested in advancing WPI's career programs together with representatives from a broad range of companies—including smaller companies that don't recruit at the Institute—to talk about WPI's educational programs and about what employers seek in its graduates.

Showcase of Colleges, a program developed by career development officers at the colleges of the Worcester Consortium for Higher Education, is aimed at reaching smaller employers in the Worcester area. Through the program, administrators from the 10 consortium colleges explain to these prospective employers what their graduates have to offer the job market. "We're opening up a valuable new dialogue with this program," Harrison says.

Keeping WPI in the eye of industry is a constant concern for the CDC. Harrison is active as diversity advancement chairman and member of the board of directors of the Mid-Atlantic Placement Association, a group that includes college and university placement officers and corporate recruiters. She and William Trask, alumni counselor and former director of the Office of Graduate and Career Plans (now CDC), are also active in the Eastern College Employer Network. Both organizations are subsets of the National College Placement Council.

Mary Beth Harrity works with more than 100 industries to place undergraduate students in work assignments. Brad Groves, assistant CDC director, Karl vanLeer, employment counselor, and John Litster, job development coordinator, also keep in contact with industry. Litster, for example, is active in the Greater Worcester Chamber of Commerce.

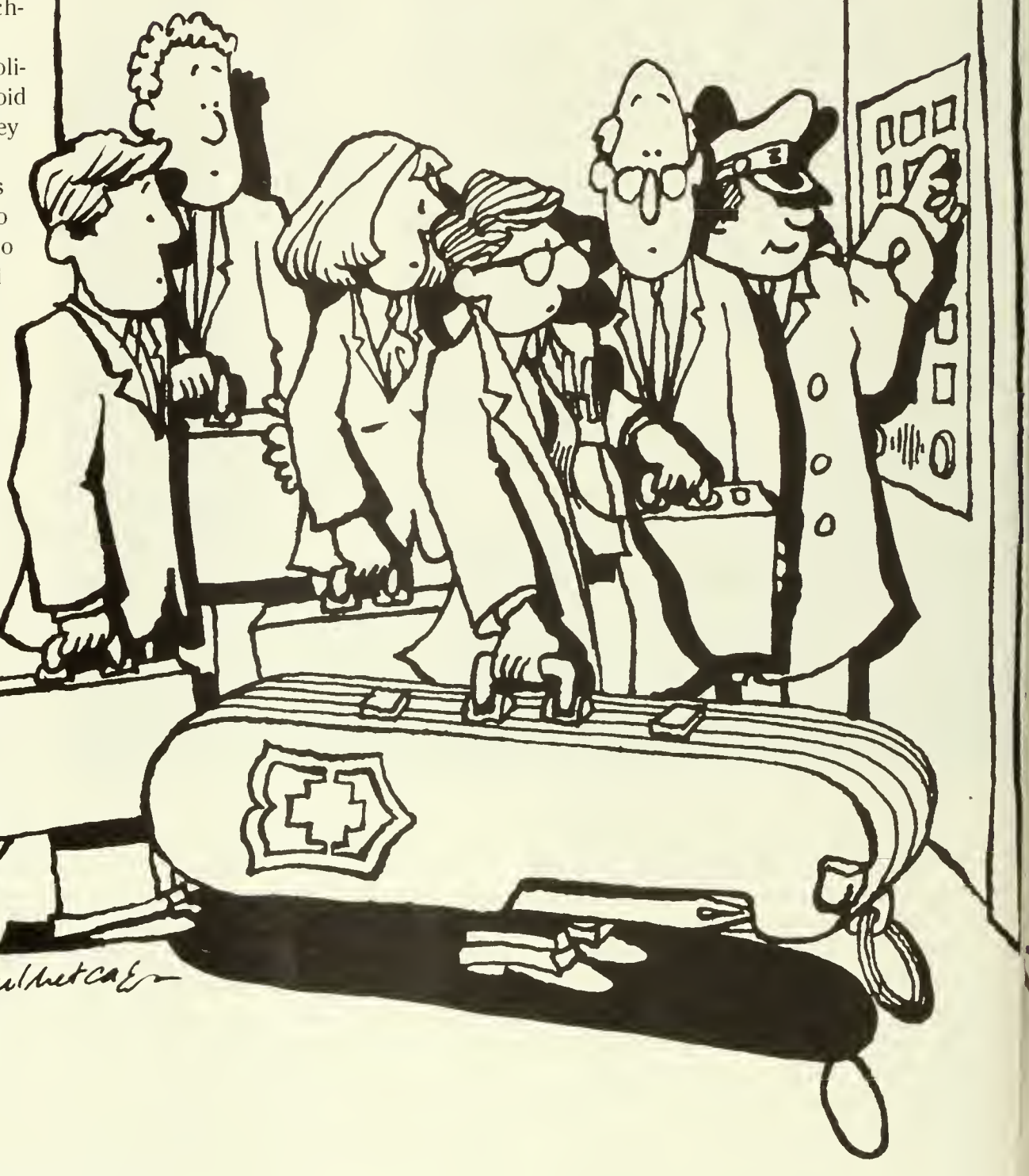
"Being part of these business-oriented organizations is important to WPI," Harrison notes. "It's a two-way street. We talk to employers about our needs and they talk to us about theirs."

One of the CDC's most pressing current needs is for a new home. Located in the former library and chapel on the third floor of Boynton Hall, the CDC has the advantage of being surrounded by the beautiful stained-glass windows designed by Percy "Pete" Marsaw '30. But the room has grown too small for the expanding CDC operation and the cubicles in which recruiters meet with students do not afford much privacy.

To rectify these problems, the center will move into newly renovated quarters in the first floor and lower level of Sanford Riley Hall in September 1995. The Admissions Office will move to Sanford Riley at the same time. On the first floor, the CDC will have a reception area, staff offices and a print and video library. Eight private interviewing rooms will be constructed on the lower level. "The new office should add greatly to the confidence of students and the convenience of interviewers," Harrison says.

She also notes that the CDC is looking at how new and evolving computer and communications technologies can expand students' job-hunting horizons. Already, her office is gearing up to use teleconferencing equipment owned by WPI to begin offering video telephone interviewing, which will enable employers to interview students from a distance. "Before long," Harrison says, "we may see a student and an interviewer talking face to face even though one is in Worcester and the other in Cincinnati."

A Workplace Survival Kit for Technical Professionals



Gone are the days when scientists donned fresh white lab coats and spent the day without human contact, except perhaps with other lab personnel or the subjects of their experiments. And engineers no longer have the luxury of living their professional lives in a vacuum, having the computer as their only connection to the outside world. Technical professionals today must learn modern survival techniques.

Most technical people consider "politics" a negative word. They'd rather avoid having to deal with such issues. But if they don't learn to successfully participate in the political environment of today's workplace, they may not be around to help create tomorrow's new reality. To make sure they will have the time and resources they need to think and create, they must develop political savvy.

Political savvy is the ability to realistically size up a situation—what are the relationships between the players and what is at stake (someone's reputation, a new job, a career, etc.)? It also means understanding who has the power, who controls the finances, and what are each player's motives. It's important to evaluate the players' ethics. An unethical person reacts to political situations in a different manner than someone with his or her ethics in place. Sizing up all the nuances of a situation can be a tricky task.

Political savvy has many benefits, the most important being improved job security. Employees who appreciate their political environment are better able to survive the cuts, slices and stabs of the system. And gaining insight into the motives and ethics of those who have power over your career puts you in a better position to

By Barbara Veal

ILLUSTRATION BY PAUL METCALF

predict their behavior. Your potential for promotion also grows as you become more politically astute.

It's also important to be aware of the career tracks that a company or other employer offers. In that way, you can realistically evaluate if an employer is a good match with your needs, talents and professional goals. Historically, most employers have encouraged their employees to worry more about meeting the employer's goals than their own. But in today's more employee-oriented climate, professionals have more freedom to work on their own goals, as well. The result is usually more productivity and better results—for employer and employee alike.

Keeping Pace

Change is another issue all employees face today. On the global scale, change means right-sizing, reorganizations, corporate acquisitions and spin-offs. Changes like these inevitably affect all employees—even those who retain their jobs. On a more personal scale, change can mean making a horizontal move within a company, getting new management as a result of a reorganization, or moving to a new employer.

Employees must have a high level of flexibility to survive and function in a changing environment without losing perspective. They must also stay alert to and keep pace with the changing political climate to come out with the position—and the career—they want.

Keeping Sharp

Keeping your technical skills at their peak can be a time-consuming task. Current research suggests that you spend a minimum of one hour a day reading, studying and learning new information about your professional field. That may sound like a lot of time, but it amounts to just seven hours a week. Study time must be a priority, or it will inevitably lose out to something that seems more urgent or important at the time.

There are dozens of professional publications in any field. The best way to sort through the massive amount of information available in your field is to visit the library and find a group of four to six well-written publications that contain information of interest and which seem to keep abreast of industry trends. It may take several trips to the library to choose the best reading materials, but the time will be well spent.

Another good way to keep up with industry trends is to attend professional conferences and trade shows, which can provide you with a wealth of new information. The newsgroups, mailing lists and information databases located on the Internet (see page 8) and similar services provided by on-line sources like CompuServe and America Online can also be invaluable resources for those who have the equipment to tap into them.

Representing your company or institution at a professional organization, such as IEEE (Institute of Electrical and Electronics Engineers) or ANSI (American National Standards Institute), can be an invaluable learning experience that will also benefit your employer immensely. It is an opportunity to gain exposure to the industry's best minds and to share your own viewpoints to help shape future technology and technical trends.

Managing Expectations

Another important but often overlooked skill that can help pave the way for a more successful career is the art of managing expectations. It's also a skill that saves time, effort and expense in the long run. Since co-workers and supervisors are not mind-readers, the easiest way to manage your professional and personal relationship is to verbalize the expectations you have of others: expectations about their performance, about how you want them to interact with you, about the roles and tasks for which they're responsible, and so on.

Talking about as many workplace issues as possible will increase the potential success of any project and make for smoother working relationships. A good way to be certain of what you've worked out is to put it in writing and have the other parties confirm that they see things the same way. Everyone wants to do a great job, but unless you know in advance what is expected of you, you're at a disadvantage and you're likely to end up being frustrated.

Managing Time

Perhaps the most valuable skill you can learn in your career is the ability to manage time and prioritize tasks. Everyone has to deal with unscheduled crises and interruptions. You need to learn to handle them without neglecting your priorities and without losing your ability to concentrate on what is really important. The key is respecting the value of your time by not permitting it to be used up with petty time sinks.

There are many good classes, seminars and systems that can teach you time-management skills. You may need to try several before you find one that works for you. You may also find that a time-management system that works well in your current job may not meet the needs of a new position. Experimentation is the key to finding the best time-management system for you and your job.

Tackling Negotiation

Most people dread negotiation because it is a form of conflict. But in reality, we negotiate on a daily basis in our personal and work lives. We negotiate with a salesperson over the price of a car, with a spouse over housework or childcare responsibilities, or with outside vendors on the terms of a contract. Anyone can learn to negotiate for their own benefit and that of their employer.

Technical professionals should become familiar with the art of negotiating and recognize it as a valuable skill. You won't always be able to assume that others will effectively negotiate for you. You may often be the only person with the technical expertise and professional qualifications to participate in important negotiations. You need to be ready and able to step up to the challenge.

As with the other skills mentioned in this article, there are classes, seminars, tapes and books that will teach you to be a better negotiator. Take a seminar that includes practice negotiations; that's the best way to learn useful negotiating tactics. It's sometimes scary to practice new skills in front of a room full of people, but that's a lot less scary than practicing in front of a customer or a new department head.

Survival of the Fittest

Today's professional marketplace is highly competitive. To survive and flourish, you need the best and most up-to-date skills. And to prepare for the challenges of tomorrow, you need to take advantage of the time you have today and use it wisely. It is within your control to set the stage for continued success in your career. You just need to accept responsibility for your own survival skills and go for it.

—Veal is a product manager in the Microelectronic Products Division of NCR in Fort Collins, Colo., a division of AT&T Global Information Solutions.

As a child, Lee Kenseth Abel '95 escaped the killing fields of Cambodia and ultimately found a new life with a family in America. But he always wondered what had happened to the family he left behind. This year, he had the chance to find out.

The Return of the Golden One

By Joan Killough-Miller

It was early January 1994 as Lee Kenseth Abel's plane touched down in Thailand. For the WPI junior, it was the first time he would set foot on Southeast Asian soil in more than five years. He was there to complete a project at WPI's Bangkok Project Center. But first, there was a more personal mission to accomplish.

He flew from Bangkok to Phnom Penh, the capital of neighboring Cambodia. There he bought a map and hired a car. After a few days of asking around, he directed his driver to take him to a small village about 35 miles outside of the city. Following Abel's directions, the driver stopped in front of a small house. A dog was asleep outside and two motorcycles were tucked underneath the structure. A sleepy-looking woman came to the door.

"May I help you?" she asked. "Who are you looking for?" He replied in Khmer, his native tongue, but his accent, colored by more than a decade in Thailand and the U.S., made his words unclear. She seemed to think that Abel, with his Western clothing, was a friend of her older son, who had once worked for the United Nations.

He asked her name and she told him. Then he called her "Mom." But after so many years, the woman seemed doubtful that this young man could be her long-lost son. She looked at him, struggling for recognition. Then she grasped his face and turned his head to the side. There, under his right ear, she saw a familiar mole. She knew.

"She put her arms around me and cried out. Then she fainted," Abel says. "They all thought I was dead. She had gone to fortune tellers; some said alive, some said dead. She cried and cried. Me? I was just too overwhelmed...I couldn't really cry."

Despite the contradictory intelligence from the fortune tellers, his birth mother had never lost faith that her son was alive. Until that day, Abel had not known for sure if any of his relatives had survived Cambodia's killing fields, or whether he would be able to track down the family he had lost almost 20 years before.

It was in the spring of 1975 that the Khmer Rouge, soldiers of the Cambodian communist insurrection, began their final offensive against the American-backed Lon Nol government. Five-year-old Ly Chhem was living with relatives in Phnom Penh. His country had been at war for almost a decade. Prince Sihanouk, Cambodia's long-time leader, had been ousted in a right-wing coup one month before his birth. Hundreds of Cambodian villagers were being killed or left homeless as America drove deeper into the border with an illegal bombing campaign staged to flush out Viet Cong sanctuaries.

To escape the shelling of the capital, Ly was sent with his grandparents to Battambang, a rural western province that borders Thailand. The rest of the family was to follow, but they could not have known that on

April 17, just two weeks after Ly's departure, the Khmer Rouge would storm Phnom Penh, blowing up bridges, halting air traffic, and ordering a massive evacuation of the city dwellers to prison camps and torture centers in rural regions of the country.

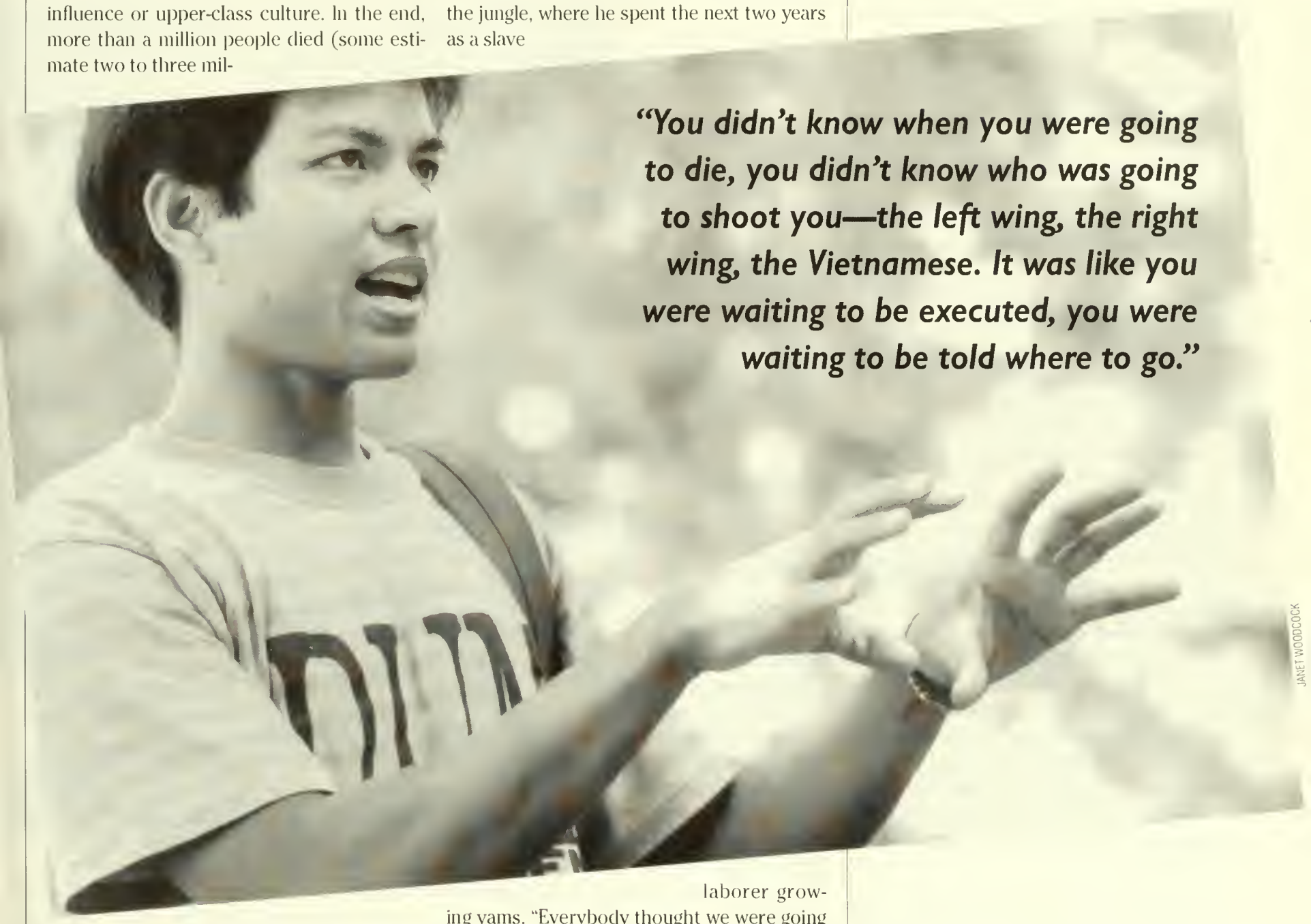
It was the beginning of four years of genocide for so-called Democratic Kampuchea, under the brutal leadership of Pol Pot. The Khmer Rouge targeted the wealthy, educated classes as enemies of communism. Their reforms included the execution of anyone connected with the former government and the annihilation of all traces of foreign influence or upper-class culture. In the end, more than a million people died (some estimate two to three million) by slaughter in the infamous "killing fields," from overwork and starvation in labor camps, or from the widespread disease and famine that ensued when Pol Pot closed Cambodia's borders to foreign aid and trade.

In Battambang, Ly's grandparents perished from lack of food. Left on his own at an age when his American contemporaries were still in kindergarten, he was soon swept up by the Khmer Rouge, along with orphans of the slaughtered ruling class. Ly is not sure if his own father was associated with the pre-Communist government. He thinks he remembers seeing him in uniform on occasion, but cannot recall his face. Years later he learned that his father was imprisoned by the Khmer Rouge and died of starvation.

Ly spent the next two years in a Khmer Rouge camp. "When the camp started, there were maybe 2,000 children under the age of 10. At the end...600," he says softly. "We were too young to execute, so they starved us and got what work they could out of us."

When he left the camp, he was feverish and so weak he could not move his legs. He and other survivors were sent by train into the jungle, where he spent the next two years as a slave laborer growing yams. "Everybody thought we were going to be executed," he says. "But they said it's a waste to kill us. Why not just let us die of malaria, and make some food for them?"

In 1979, the Pol Pot government was overthrown by Vietnamese Communists and rival left-wing factions of the Khmer Rouge, with help from the Soviet Union. The country was in chaos, and the jungles still dangerous. "You didn't know when you were going to die, you didn't know who was going to shoot you—the left wing, the right wing, the Vietnamese," Abel recalls. "It was like you were waiting to be executed, you were



"You didn't know when you were going to die, you didn't know who was going to shoot you—the left wing, the right wing, the Vietnamese. It was like you were waiting to be executed, you were waiting to be told where to go."

JANET WOODCOCK

"Pure luck and lots of skill and hard work" led Lee Kenseth Abel, above, back to the village in Cambodia where his mother resided. His reunion with her after almost 20 years, opposite page, was the culmination of a remarkable and powerful tale.

waiting to be told where to go. I was too young to know anything. I was hungry. I just went day by day."

Nine-year-old Ly was evacuated from the jungle. He returned to Phnom Penh to look for his family, but the capital had been emptied. "It was so quiet in the city, like a ghost town," he remembers. The war-ravaged country had been liberated from the Khmer Rouge, but conditions were still harsh. Food was scarce in the government orphanage where he spent several months. A top scholar himself, Ly noticed that among the older children, superior students were being sent off to Hanoi and to the U.S.S.R. He knew he would be drafted into the army as soon as he came of age.

Ly saw only one chance for survival: refugee camps were being set up in Thailand, and he'd heard there was plenty of food there and a chance to seek sanctuary in the United States. He fled the orphanage with four children, not much older than himself. They hopped a ride on the top of a train, then traveled for three days on foot. It was a dangerous journey. They had to duck snipers, fend off robbers and avoid land mines. And the Khmer Rouge were still fighting at the border. He was separated from his companions, only one of whom made it to Thailand alive. Ly finally crossed the border and managed to find a refugee camp.

Run by the U.N., it was "basically just another concentration camp," Abel says, "but they were kind to us and didn't starve us or beat us up." There was no fresh food, supplies were short, and the refugees had little freedom. They got some protection from young, untrained guards, who were sometimes drunk, but at night were left to fend for themselves.

Even in the chaos of the camps, Ly kept up his studies. He couldn't afford private tutoring, but sat outside, rain or shine, to listen in on the sessions. It became a running joke that he could always be found in the camp library, in reality just a bamboo pavilion. After three years his application for refugee status was accepted; he was cleared to go to the United States under the sponsorship of David W. Rosenberg of the Lutheran Immigration and Refugee Service.

Next came a processing center in the Philippines, where refugees were checked for disease, taught some rudimentary English, and briefed on American culture. In 1987, Ly Chhem made it to the United States and went to live in Amherst, Mass., with Elaine Kenseth-Abel, a friend and former co-worker of Rosenberg's, and Chris Abel. Elaine had already met Ly, having gone to the camp in Thailand to search for relatives of other Cambodian refugees living in the U.S.

The Abels, who later moved to Miller's Falls, did not adopt Ly, since they felt adoption was not appropriate at his age and because of uncertainty over the fate of his natural parents. Still, he refers to Chris, Elaine and their four children as his "foster" family.

Ly completed a year of high school in Amherst, then earned his diploma in 1991at the Northfield Mount Hermon School, where he excelled in mathematics and science. He wanted to attend a small engineering school in New England, and WPI appealed to him—to the great delight of his American grandfather, Wally Abel '39, who showed Ly around the campus and introduced him to faculty members.

"He's had to fight for everything by himself, and he tends to keep his burdens to himself. In the last few years, he's opened up more and more, and he's talking about what he's been through."

"Ly was the only science-minded grandchild," Kenseth-Abel says. In the end, he chose WPI for its top ranking in *U.S. News & World Report* and its reputation for quality undergraduate programs.

Wally Abel compares the adventures of his "adopted" grandchild to a fairy tale—from his narrow escape from Cambodia, to his new life as a successful engineering student. "He's had to fight for everything by himself, and he tends to keep his burdens to himself," Abel says. "In the last few years he's opened up more and more, and he's started talking about what he's been through."

When it came time to choose a topic for his Interactive Qualifying Project, Ly learned about the Bangkok Project Center, where he would go with four other students to study cross-cultural management of multinational corporations. He saw an opportunity to go back to Cambodia and search for surviving relatives, a mission that had been on his mind for years. "I think it was always there... the needing to know," says Kenseth-Abel."He would sometimes get glimmers that someone was still alive."

Years ago, while he was visiting a Buddhist temple in Rhode Island, a Khmer woman recognized Ly from the refugee camp, and helped him get in touch with cousins in Battambang, where she also had relatives. He was told that someone had seen his mother alive in 1980, but rumors like that abound in refugee communities.

He already knew that his father and two of his brothers were dead, but women stood a better chance of surviving the Khmer Rouge. Although women were also enslaved

and tortured, men took the brunt of the executions. It has been estimated that of the victims of Cambodia's holocaust, 80 percent were males between the ages of 20 and 50.

The Abels feared that without an American passport, Ly would face hassles at the Cambodian border. After conversations with Marché Haddad, WPI's assistant director of global programs, they decided that he should apply for American citizenship. Ly passed the required test in October 1993, but was told he would have to wait five to six months for the next swearing-in ceremony in Boston—too late for his scheduled January departure.

The Abels appealed to Sen. Edward M. Kennedy's office, which contacted the U.S. Immigration and Naturalization Service. A local Superior Court judge agreed to swear Ly in at the Franklin County courthouse. "Between a drug dealer and a wife beater, they stopped to have this nice little naturalization ceremony," recalls Kenseth-Abel. Just two days before Christmas, Ly Chhem got his wish: he became an American citizen and had his name legally changed to Lee Kenseth Abel. He got his passport in record time, and just days before his departure he was issued a new visa for Thailand with his American name.

It was "pure luck and lots of skill and hard work" that led him to find his mother in the village where she had grown up. He just kept asking around on the streets of Phnom Penh, until he made contact with people who knew his relatives. "In Cambodia, everybody is related, and everybody knows everyone else," he says.

His mother took him to see his three surviving brothers. Abel says he found his family members living comfortably, although from his perspective as an American engineering student, Cambodia seemed undeveloped. "It was like going back 50, 60, 70 years," he says. The level of technology and mass communication is improving in the cities, he notes, but in his mother's village there is no electricity or running water and there are no paved roads. A trip to Phnom Penh is required to mail a letter and newspapers don't regularly reach the countryside.

By the time he found his mother, Abel was almost out of time. With his project in Thailand about to begin, he had only a few days with his mother and brothers; most of that was spent traveling to meet scattered relatives. Along the way he did have time to cause a commotion in Phnom Penh by roller blading to a stadium to see a soccer match.

"They stopped the game and the players, the police...everyone wanted to see my roller blades, to touch them," he says. "Thousands of people wanted to see me skate. So I did spins and jumps and turns. I played basketball on my roller blades. Then I skated to Sihanouk's palace and there were almost some accidents as people slowed down to look at me. About 30 children ran after me."

When his project was finished, Abel returned to Cambodia for a brief but less-frenzied visit. But lack of time wasn't the only obstacle he encountered in reuniting with his family. Although his mother and brothers were overjoyed at finding him alive, he was still a stranger to them, he says. And in their eyes, he was a foreigner.

"It was a shock for everybody," he says of the reunion. "It's very strange; there were so many mixed emotions. Asian people are not very open to people they don't know. To them, I seemed like a tourist—the way I wore my clothes and the way I hung around and talked with Americans and Europeans."

Then there was the irony of retaining childhood memories—for example, fights over toys with his cousins—but not recognizing the people from those memories when they greeted him as adults. When he asked after a favorite cousin, he was told, "But he is standing right next to you!" What was hardest to accept was the distance that had grown between him and his Cambodian mother.

"Before I went back to Cambodia, I didn't really appreciate my life. Now I see that I'm very lucky to be alive and to get this kind of education."

"She knows I'm her son, but I'm no longer the boy that she once knew," he says. "She tried to imagine what kind of life I'd been living, what kind of joys I'd had, or what kind of suffering I went through. She tried to get close to me. I thought when I saw her, I was going to feel very close to her. It was very disappointing."

He confided his feelings in a phone call to Elaine Kenseth-Abel after his return to Thailand. "To tell you the truth, Mom," he said, "I feel closer to you than my real mom. I just don't know her like I know you."

After a few days of adjusting and playing with his younger relatives, Abel felt his Cambodian family begin to open up to him. He discovered that although he is considered quiet and reserved by American standards, among Cambodians he stands out as being active and outspoken.

He also learned that he is two years younger than he thought he was. The date of birth on his immigration papers, Dec. 31, 1968, was actually made up by immigration officials in Thailand, who were anxious to finish work and get to a New Year's Eve party. His real birthday is April 28, 1970, making him the same age as his American brother Leif. His Cambodian mother told him that he also has a half-brother, named Stephen Bell, living in the U.S. Abel says he believes he is in Connecticut, but so far has been unable to trace him.

Abel plans to stay in contact with his newfound family, although he knows the inefficiency of the Cambodian postal system and the effort it takes for people in the countryside to mail letters will make that difficult. Abel has sent letters and pictures to his family with friends traveling to Cambodia and has faxed messages though a Cambodian business owner he knows. So far, there has been no reply.

He would like to visit again, but knows that there is no future for him in his homeland. Cambodia has no commercial industry and there are no jobs for a mechanical engineering major whose field of interest is manufacturing. However, his IQP on cross-cultural management opened his eyes to global opportunities with American companies that are expanding elsewhere in Asia.

When multinational companies are ready to move into Cambodia, he will be ready. "At WPI I am a lowly undergraduate," he says, "but in Cambodia, I am an expert. They need someone who understands both cultures." But for now, the demand for trained engineers in Thailand and some other Asian countries is so high, he says, "they grab whatever they can find."

Abel says his journey back to his homeland taught him a great deal about himself. "Before I went back to Cambodia, I didn't really appreciate my life," says Abel. "Now I see that I'm very lucky to be alive and to get this kind of education. If I stayed in Cambodia, chances are I would be one of those people who barely finished junior high, or I could have been drafted into the army and shot and killed."

One other thing he learned in Cambodia was his real name, the one his mother called him—Sovann Ly. "Sovann means Golden One," he told Kenseth-Abel by phone, "smartest, most fortunate. The stars and the planets and all the heavens were all great when I was born. Sovann means I would never die, good and kind people would always help me, and you know, Mom, it's true...I mean, it's really true."

"Shy Inventor" Kept Byrd on Course

By Joan Killough-Miller

Albert H. Bumstead didn't stick around WPI long enough to earn a diploma, but without him Admiral Richard E. Byrd might still be circling the North Pole—that is, if he'd been able to find it in the first place. Byrd swore by the "sun compass" invented by Bumstead, a member of the Class of 1898. "I do not hesitate to say that without it we could not have reached the poles," he once remarked. "[The instrument] made it possible to fly with confidence to the North Pole, and to find our way back to our bases."

Bumstead's compasses also went along to Antarctica with Byrd, who persisted in exploring places where proximity to the Earth's magnetic poles made a traditional mariner's compass useless. When Byrd said that he wished he could navigate at night as well as he did by day, Bumstead took that to heart, too. He came up with a simple and practical system based on a sextant reading of Polaris, the Pole Star.

Soon Byrd was conferring with Bumstead before each voyage. The explorer carried a tiny American flag to the South Pole, which was later mounted and hung on the Bumsteads' dining room wall. Byrd also named a mountain in the Queen Maude Range, near the South Pole, for the inventor.

In addition to the Bumstead sun compass and Mount Bumstead, some 38 million maps also bear his name. In his 25 years with the National Geographic Society, Bumstead produced maps of every part of the world and revolutionized the science of cartography with inventions that made mapmaking quicker, neater and more accurate.

Adjectives like "modest," "quiet" and "unobtrusive" abound in articles about Bumstead, who was often described as the

PHOTOS COURTESY OF ROBERT BUMSTEAD '31

Above, Bumstead, left, explains the operation of his sun compass to Admiral Byrd. Opposite page, Bumstead, standing, with Osgood Hardy, the assistant cartographer on the 1912 expedition to Peru.

"shy inventor." "I have always been handy with my hands," he said, in a humble explanation of his genius. But a mysterious classmate, apparently a WPI alumnus and a reporter for the *Washington Evening Star,* described the real Bumstead as two different people.

The profile described Albert H. Bumstead, chief cartographer, as "an elderly gentleman with graying hair and mustache, both a bit unruly, [who] speaks in an odd low monotone." His counterpart, "Al," might be encountered almost any night, scurrying nervously around the basement of his Washington, D.C., home.

"He has the same graying hair and mustache, still unruly—perhaps more unruly—but the voice is different," the writer explained. "It is less even; it is more animated. There is a difference of about 20 years in the ages of Albert H. Bumstead and Al, in favor of the latter. Yet they are the same man. Al, in the cellar, is a magician; Albert, in the penthouse [his top floor office at National Geographic headquarters], is chief cartographer, surrounded by maps of every charter corner of the world."

The article, which appeared in 1934, has no byline, yet its author describes Bumstead's monotone as "a voice which was recognized recently over the phone by an old classmate who had seen him but once before in 34 years." The *WPI Journal* noted the article in a news column, but was unable to identify the author. "Too bad good feature writers are so often nameless," it lamented.

As he went through life, Bumstead pretty much invented what he needed, or what he thought others needed, from recycled parts and everyday objects.

According to his 1940 obituary in the *Journal,* Bumstead studied electrical engineering at WPI for two years, then withdrew, although he was earning high grades in most subjects. After leaving the Institute, he studied geography at Harvard for a year. He worked briefly as topographer for the U.S. Geological Survey, then retired to Townsend Harbor, Mass., where he spent nine years "trying to run a farm and finding I couldn't," according to his own admission.

In 1912 Bumstead was recruited by Hiram Bingham as chief topographer on an expedition to Peru that uncovered Machu Picchu, "Lost City of the Incas." When he returned, he was appointed to the National Geographic Society.

Bumstead and his wife, Annie Sweeney, had five children. Two sons attended WPI. G. Newman Bumstead '30 followed in his father's footsteps, eventually becoming chief of geographic art for the National Geographic Society. He died in 1967. Robert Bumstead '31 was the only Bumstead to receive a degree from the Institute. A retired mechanical engineer and insurance executive, he lives in New Hampshire.

As he went through life, Bumstead pretty much invented what he needed, or what he thought others needed, from recycled parts and everyday objects. The famous sun compass was actually a retrofitted alarm clock, with a 24-hour dial plate and a hand to cast a shadow on the face. It was developed in three weeks and rushed to Byrd just before takeoff. When Bumstead developed a fascination for lapidary, the art of grinding and polishing gemstones, his basement workshop gave birth to new apparatuses for his hobby. With his brother Ralph, he created a device for rapid transmission of stock quotations that established the basis for later communications technology.

During World War I, Bumstead approached the war department with a new map projector that laid down parallels and meridians in 20 minutes, as opposed to three or four hours for the ordinary method. He turned out an accurate map of the European theater of operations and later declined a patent on the new invention, giving it over for government use. Although his patriotism was hailed in Washington, his New England neighbors were more leery.

In 1917, residents of Townsend Harbor feared that Bumstead was transmitting intelligence to the Germans. Neighbors reported the suspected spy to the Fitchburg police. When authorities investigated the property, they found antennas wired to the elm trees—evidence of an innocent "wireless" operator who had an endless fascination with new technologies. As for Bumstead, he was off in Peru, on a second expedition to explore newly discovered relics from the distant past.

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WPI Journal

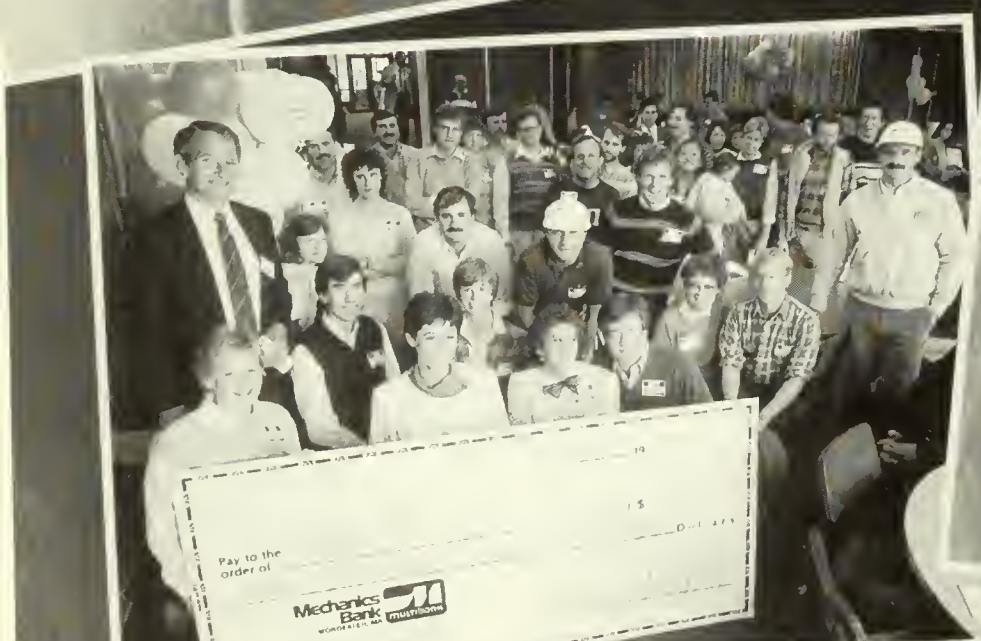
FALL 1994

The Quest for a New WPI

The Annual Report of the Institute

plus:

A Look Back at the Presidency of Jon C. Strauss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Front Cover: On the lawn in front of One Drury Lane, their home for more than nine years, are Jon and Jean Strauss and their sons, Kristoffer, left, and Jonathon. Photo by Janet Woodcock. **Opposite:** The many roles of a college president as carried out by Jon C. Strauss. **Back Cover:** A crunchy blanket of fallen leaves covers the hillside by Gordon Library. Photo by Janet Woodcock.

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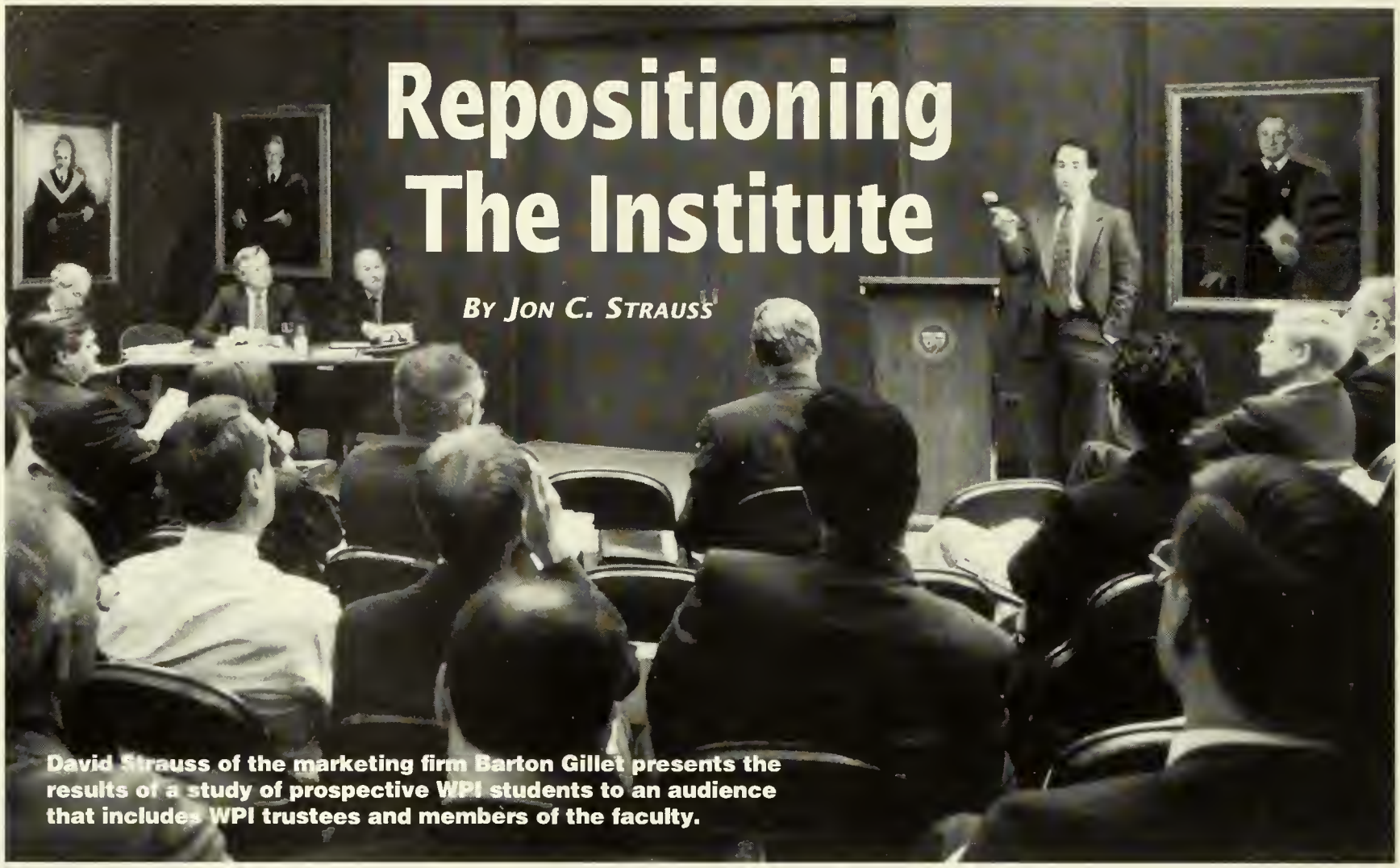
Repositioning The Institute

By Jon C. Strauss



NEIL NORUM

David Strauss of the marketing firm Barton Gillet presents the results of a study of prospective WPI students to an audience that includes WPI trustees and members of the faculty.

The New WPI and Beyond

Last year's annual report was prefaced with an editor's note that set forth an ambitious agenda: "In fiscal year 1993, the college completed a major period of self-evaluation and began the weighty task of determining how it will mold itself into the type of institution best able to thrive and grow in the decades ahead." As you will see, we have indeed been asking ourselves what it means to thrive and grow in these challenging times. We've also come to appreciate that we have not yet completed—nor will we complete any time soon—our self-evaluation. In fact, continuous critical self-appraisal is the key to the growth in excellence to which we aspire.

This annual report is the ninth and last in the series spanning my presidency of WPI. It begins with a review of the actions taken over the past year in response to the recommendations of the Blue Ribbon Task Force. The task force's report was the focus of my message in the 1992-93 annual report.

One action taken was the hiring of marketing consultants Barton Gillet to study how WPI is perceived within its most important marketplace: the group of potential students. This report goes on to summarize our efforts this year to refocus WPI's image in that marketplace in response to Barton Gillet's recommendations.

The report concludes with a look at our initial planning efforts for WPI's next comprehensive fund-raising campaign. The campaign will be designed to develop the funds needed to position WPI to best serve the needs of our students, our faculty and our society as we enter a new millennium.

The emphasis on planning you will find in the pages that follow will not surprise readers of earlier editions of this annual report series. My first report, for the 1985-86 fiscal year, established an agenda for strategic excellence; each successive report has commented on some aspect of our progress toward that agenda. This year's report continues that commentary.

Background

To appreciate fully why it seems necessary to reposition WPI, one must begin by looking back to the beginning of this decade. At that time, WPI was just concluding the highly successful Campaign for Excellence, which ultimately yielded $63.7 million—121 percent of its $52.5 million goal. At the request of the Board of Trustees, a steering committee was at work developing a new strategic plan to guide WPI's development through the 1990s. The resulting plan, which was approved by the faculty and the trustees in the spring of 1990, has six goals:

Goal 1: ***Enhance the Level of Excellence in Undergraduate Education***

Goal 2: ***Enhance the Level of Excellence in Graduate Education***

Goal 3: ***Increase the Quality and Quantity of Research and its Recognition***

Goal 4: ***Enhance the Quality of Life on Campus***

Goal 5: ***Meet the Needs of Professionals for Continuing Education***

Goal 6: ***Strengthen WPI's External Relationships***

With the passage of the strategic plan, we began focusing our operations toward achieving these goals; each year since we've highlighted our progress in the annual report. But by the fall of 1991, it was becoming obvious that the strategic plan might have to be rethought. Several external factors, most particularly the dramatically increasing cost of institutional financial aid, were placing enormous budgetary pressure on WPI, creating the prospect of an even more challenging future than that envisioned by the plan's drafters.

Accordingly, the Blue Ribbon Task Force, whose members were drawn from the faculty, staff, student body and Board of Trustees, was charged with developing a comprehensive plan for the Institute. Reflecting the strategic plan where possible, it would maintain and enhance WPI as it charted a course through the many demographic, societal and financial uncertainties of the next decade. The plan also had to assure the financial equilibrium of the operating and capital budgets.

Given the magnitude of its objective, it is not surprising that the Blue Ribbon Task Force did not succeed completely in developing a comprehensive plan. But it did confirm that we face vexing, largely externally imposed financial problems. It also developed a framework for addressing them in the contexts of quality of life, academic experience and financial equilibrium.

In its final report, the BRTF made a number of recommendations, but its vision for WPI's future is probably best captured by the following excerpt from the executive summary:

"Quality in all we do is essential to our continuing success. WPI must take advantage of its strengths in technology and broaden along technical lines; be sensitive to the needs of its customers, both financially and educationally; be flexible programmatically to meet their needs; and produce a higher quality program at a lower consumer and institutional cost."

...and in these two recommendations:

"That the WPI of the 21st century be a technologically based comprehensive university."

"That WPI's 'broadening' include a more vital role for the Humanities and Social Science and Policy Studies departments in contributing to these emerging interface technologies...."

Under the guidance of the Community Council, which was formed in 1992-93 in response to a recommendation of the Commission on Residential and Social Life, a number of initiatives were begun in the fall of 1993 to respond to the BRTF recommendations. These included

- four campus open forums. These explored each of the BRTF emphasis areas—quality of life, academic experience and financial equilibrium—and engaged the community in a discussion about parking under the aegis of the new Parking Committee.
- the hiring of the marketing firm of Barton Gillet to determine how prospective students would receive the BRTF recommendations relating to the academic experience.
- the soliciting of proposals from the faculty to develop academic programs in "interface disciplines." These would build on our considerable existing strengths and broaden WPI's appeal to students who might not otherwise consider matriculating at what they perceive to be a narrow engineering school.

As the fall of 1993 progressed, it became clear that the financial problems facing WPI were even more difficult than the BRTF had foreseen. Because of the continuing escalation in the amount of institutional financial aid WPI must make available to remain competitive, total tuition revenue net of institutional financial aid increased by just 1 percent in 1992-93 and was projected to increase by only 2 percent in 1993-94—even with constant enrollments.

Moreover, applications were dropping and it appeared that quality might have to suffer to maintain enrollment. These indicators, combined with a continuing national decline in interest in technological higher education, suggested that a course marked by "business as usual" would be fraught with difficulty. Ways needed to be found to increase net revenue more rapidly than the costs of instruction.

Repositioning

In its study of WPI's prospective student marketplace, Barton Gillet surveyed a total of 23,700 young men and women in the fall of 1993: 21,000 students who inquired about WPI during 1992-93 but never applied for admission (inquirers); 2,000 students who applied and were accepted, but who chose not to enroll (no-shows); and 700 students who matriculated as members of the Class of 1997 (freshmen). The survey uncovered a number of interesting—almost startling—facts about how prospective students perceive us. For example:

- 24 percent of the inquirers and 15 percent of the no-shows expressed an interest in the biological sciences; only 4 percent of the freshmen expressed such an interest.
- 24 percent of the inquirers were interested in medical careers; only 8 percent of the no-shows and 7 percent of the freshmen were so inclined.
- The factor cited most often by inquirers and no-shows to explain why they did not choose WPI was a preference for a more all-around school (read university) over a technological institution (67 percent of inquirers cited this as a major reason and 17 percent said it was a concern; it was a major reason for 43 percent of no-shows and a concern for 27 percent).
- No-shows were more likely than the other groups to cite cost (39 percent major factor; 25 percent concern) and quality of life (21 percent major factor; 45 percent concern) as reasons for not choosing WPI.

Based on these and related data, Barton Gillet made several recommendations to WPI. Most important, they concluded that "only a major repositioning of WPI in the marketplace will succeed in making possible our escape from the current [financial] predicament." They said the basis for such a repositioning "already exits in the WPI Plan, the directions in which you have been leading the Institute, and some of the imaginative proposals now on the table. What is needed is a focus and a unifying platform and direction for these initiatives."

As part of this major repositioning, Barton Gillet, echoing the Blue Ribbon Task Force, recommended broadening WPI into a comprehensive university. Neither Barton Gillet nor the BRTF envisioned WPI competing with Amherst or Wesleyan for English majors. Rather, both groups were seeking ways for WPI to attract those potential applicants who would profit from our strengths in areas such as the biological sciences, but who either don't apply or choose not to attend after they've been accepted.

If we can find a way to get more of these students to apply with serious desire to enroll, we can be more selective based on the ability of our applicants to pay, thereby raising the net revenue we receive per

student. In this way, we can reduce our cost for institutional financial aid, thus relieving the financial pressures we face.

The challenge will be overcoming the obvious fears these prospective students have of being limited by attending what they perceive to be a narrowly focused engineering school. We must find ways to communicate more clearly our existing broad strengths in the life and social sciences and in the liberal and fine arts.

Once we attract these nontraditional students, who will not be seeking the rigors of a traditional engineering education, we must provide them with a stimulating and nurturing environment. The development of interface disciplines, an idea proposed by the BRTF, will help support this objective by creating academic disciplines that prepare students in the liberal arts, humanities and sciences for the increasingly technical nature of these fields, as well as for new careers that cross the boundaries between technical and nontechnical fields. We must also make progress on enhancing the breadth and quality of life at WPI.

There is little question in the minds of most members of the WPI family that WPI must increase its appeal in the marketplace for nontraditional students while preserving and enhancing its traditional strengths.

While the faculty worked to plan new programs in interface disciplines, Provost Diran Apelian and I "went on the road" last fall to meet with faculty and staff members, academic departments, students, alumni, and trustees to discuss the implications of the Barton Gillet study and the BRTF recommendations. These many meetings culminated in a combined discussion at the February 1994 retreat of the Board of Trustees. The essence of that discussion was captured in two planning papers: *The New WPI* (March 22, 1994) and *A Marketing Plan for the New WPI* (April 14, 1994).

The substance of the repositioning vision of *The New WPI* is captured in the following five fundamental hypotheses:

1. To attract and nurture students who would not traditionally matriculate at what they perceive to be only an "engineering school," we must develop student-oriented programs in such high-demand areas as the pre-health professions, environmental studies, communications and global studies.
2. To further differentiate WPI from its competitors in the marketplace, both for its programmatic excellence and its value, and to increase the employability of our graduates, the Institute should offer a new professionally oriented master's degree in all appropriate disciplines that WPI's four-year graduates could earn with just one additional year of study—possibly at a significant discount.
3. To help graduates make a rapid and successful transition from WPI into work or graduate school, we should develop preferred supplier relationships with the various markets for our graduates. In the engineering professions, this would mean developing more co-op and intern opportunities; in pre-professional areas, it could mean negotiating preferential admission programs with appropriate graduate and professional schools.
4. To respond to the concerns of prospective and matriculated students regarding the quality of life at WPI, we should accelerate our efforts to fund and build a campus center and to improve the gender, racial and cultural balance among our students, faculty and staff.
5. To emphasize the changes made in items 1 to 4, to recognize WPI's status as a university in all but name, and to broaden our appeal to the 84 percent of the inquirers in the Barton Gillet study who expressed a preference for a more all-around school, we should change our name to WPI University (a name that will still hearken back to our roots).

The New WPI also proposed a companion investment plan totaling $10 million over five years to help implement this repositioning vision. A significant portion of that investment plan was to be directed at broadly marketing WPI University as *The University of the Future*, an institution where students would be prepared to provide leadership in an increasingly technological world. Another major portion of the proposed investment was to be used to create a supportive environment for the nontraditional students we would attract with the new student-oriented programs in the pre-health professions, environmental studies, communications and global studies.

While the specifics of *The New WPI* have encountered intense criticism from faculty members and students, there is little question in the minds of most members of the WPI family that WPI must increase its appeal in the marketplace for nontraditional students while preserving and enhancing its traditional strengths. As WPI works to respond to the challenges of the marketplace, it must recognize that while it is important to continue improving the quality of its program, that will not be sufficient. Barton Gillet commented directly on this issue:

"Much of the debate at WPI seems to revolve around program quality—whether the Institute ought simply to do better what it already does. Put plainly, that is just not the issue. The market research does not indicate that prospective students have any problem with the quality of WPI's program. Rather, they prefer a more rounded institution. Most of the Institute's prospects are convinced that they will find in a broader-based university a more rewarding student life, an experience more conducive to leadership development, better preparation for professional study, a broader perspective on the world around them, and generally, a more prestigious qualification. Only a thin slice of the prospective student pie is willing to consider what is perceived to be a narrow engineering school."

To maintain progress on developing *The New WPI* vision as we seek to build consensus for future directions, the trustees in May 1994 authorized WPI to invest $600,000 beyond the approved budget. In addition to funding the first year of development for the interface disciplines, this investment will

Chemistry Professor James Dittami and student Hua Qi analyze biomolecules on an NMR scanner. Developing programs in high-demand areas like pre-health is integral to the New WPI vision.

enable WPI to continue work toward repositioning WPI to satisfy the needs of the marketplace. Specific investments will also be made in staff support for the Pre-Health Professions Program and for a women's advocacy program that will help recruit and retain women at all levels.

An ad hoc faculty committee chaired by Professor George Phillies has reviewed 18 proposals for new interface disciplines. Most of these focus on course or curriculum design for new majors or specialties that will use our existing strengths to attract new, nontraditional students. We will need special marketing efforts to alert prospective students to these exciting new opportunities. New programs have been recommended in American studies, environmental policy, international studies, pre-law, teacher certification, technology and policy, technical theater, and economics and technology. It has also been recommended that funds be allocated to expand and better market existing programs in entrepreneurship, computer networking and communications, environmental studies, pre-health studies, industrial engineering, and technical communications.

As work continues on refining and implementing *The New WPI* vision, it will be important to keep these fundamental questions in mind:

- How, in a period of no growth or even contraction, can WPI continue to benefit from the excitement, enthusiasm and new ideas that come with the recruitment of new faculty and staff members?
- How, when interest in studying technology related disciplines is dropping, and when the cost of preserving and enhancing the quality of its academic programs is outpacing the ability and desire of families to pay for a higher education in these disciplines, can WPI position itself to gain greater control over its revenue?
- How, in this period of intense competition for resources, can the Institute maintain the strengths of its effective and distinctive outcome-oriented educational program, while still striving for the efficiency necessary to prosper?
- How, when traditional federal and corporate support for education and research is static at best, does WPI make its case for support sufficiently compelling to succeed over increasingly aggressive and sophisticated competition?
- And how can we continue to increase the recognition for this distinctive institution, recognition upon which rests the success of its future recruitment and resource development efforts?

Comprehensive Campaign

Ultimately, the continuing development of *The New WPI* vision will require significant new resources; that will be the basis for a comprehensive campaign, which is already being planned by the Board of Trustees. This comprehensive campaign will raise endowment and program resources for the scholarships, fellowships, professorships and program opportunities that will support the academic and quality of life objectives of *The New WPI* vision.

Included in the program resources will be money to fund the continuing development of technology to assist in learning and teaching. For many years, knowledgeable people have predicted that the latest technology, be it radio, movies, television, computers, personal computers, CD-ROMs or multimedia, would revolutionize education. Yet the real impact of technology on education has been minimal. It now appears that computers and communications technology, in combination with powerful artificial intelligence and virtual reality software, will finally fulfill those predictions, making possible sophisticated and affordable self-paced learning.

The comprehensive campaign will raise endowment and program resources for the scholarships, fellowships, professorships and program opportunities that will support the academic and quality of life objectives of The New WPI *vision.*

A natural question then will be, what added value do students gain by attending a private institution like WPI? Beyond the value added by an outstanding faculty, leading-edge facilities, and a unique and renowned curriculum, there are the less tangible qualities summarized by the term *quality of life.* As prospective students begin to ask the "value-added question," WPI will find even greater impetus for raising the capital resources needed to transform its campus to provide the amenities associated with comprehensive universities. It will need to

- build a campus center
- upgrade its residence halls
- build a new home for the Department of Humanities and Arts
- renovate Salisbury Laboratories to create a modern facility for the life sciences
- provide a new, central location for the Office of Physical Plant
- close West Street to create a safer campus and an attractive pedestrian mall
- move parking off the central campus and "regreen" the Quadrangle
- upgrade the visual appeal of the campus
- and renovate and expand the facilities of Gordon Library

Conclusion

WPI has a truly exciting opportunity to build on its strengths as it creates the *University of the Future.* But no one can do this alone. It will be important that all members of the WPI family come together during the next year to build consensus for what the BRTF termed "bold and aggressive action." While the challenge arises from problems in attracting enough students with the ability and the desire to pay for WPI's traditional products, the market data demonstrates that these problems can be turned into opportunities. And that can be done without compromising on quality and by building on the Institute's strengths through the creation of interface disciplines.

Renovating Salisbury Laboratories to create a home for the life sciences is one of several capital projects that will likely be goals of a new comprehensive fund-raising campaign.

President's Commission and my involvement in the Association of Independent Technological Universities, the American Council on Education and other organizations, have been clearly recognized.

"But a lot of WPI's growth in recognition, of course, has been based on our accomplishments. You don't get recognized for a PR campaign. You get recognized for the accomplishments you highlight in that campaign. The fact that we've had something to say is clearly a result of the entire community's work—especially the faculty's work—and not just mine."

JANET WOODCOCK

ROBERT ARNOLD

From left, new laboratories like these for work in magnetic resonance imaging and fire science have helped build a foundation for a growing research program. The installation of a high-speed telecommunications network and the construction of Fuller Laboratories were part of a campaign to improve the Institute's computer facilities.

Some of WPI's most significant work over the past decade has been its effort to enhance its involvement in research. Before the mid-1960s, scholarship was all but nonexistent at WPI. A focused effort to spur research resulted in a 20-fold growth in research sponsorship between 1965 and 1980. But to many on the faculty, that was just a necessary first step.

In 1984 a faculty committee, chaired by James Pavlik, head of the Chemistry Department, undertook a major study on educational and professional development that culminated in a set of sweeping recommendations. These included the expansion of the Office of Graduate Studies and Research, improvements to the Institute's educational and research facilities, and the creation of funds to provide seed money for research and educational development.

President Strauss' commitment to scholarship proved to be the catalyst that helped bring about these and other changes (including the upgrading of the dean of graduate studies and research to a full-time position, the creation of the post of director of research administration, and the establishment of the Research and Educational development councils). These changes, in turn, helped build an institutional foundation for a growing research program. Another contributing factor was the recruitment of dozens of new faculty members—nearly half of the Institute's tenure-track faculty—over the past nine years.

There are many ways to measure the products of this endeavor. One is the flood of articles in refereed journals, presentations at academic conferences, and news articles that have chronicled the new knowledge uncovered by the research community at WPI. Another is the more than tripling of annual research support at WPI, from roughly $2.5 million when the Strauss presidency began to $7.9 million in the most recent academic year. One measure in which Strauss says he takes special pride is the tripling of the four-year average number of Ph.D.s awarded by WPI, a figure that currently stands at 20.

Not unrelated to the Institute's success in research—and its growing reputation in the community of scholars—is the physical infrastructure that has been built for research on the WPI campus. This includes a host of new laboratories and research centers in a wide range of disciplines, many completed or established with major awards from philanthropic foundations, corporations and government agencies, as well as the generous financial support of WPI alumni.

They include labs for aluminum casting, biomedical sensors, bioprocess engineering, ceramics processing, computational mechanics, computer and information networks, fire science, and magnetic resonance imaging, as well as centers for crystal growth in space, image understanding, inorganic membrane studies, powder metallurgy, shock/dynamics/seismic analysis, and wireless information networks.

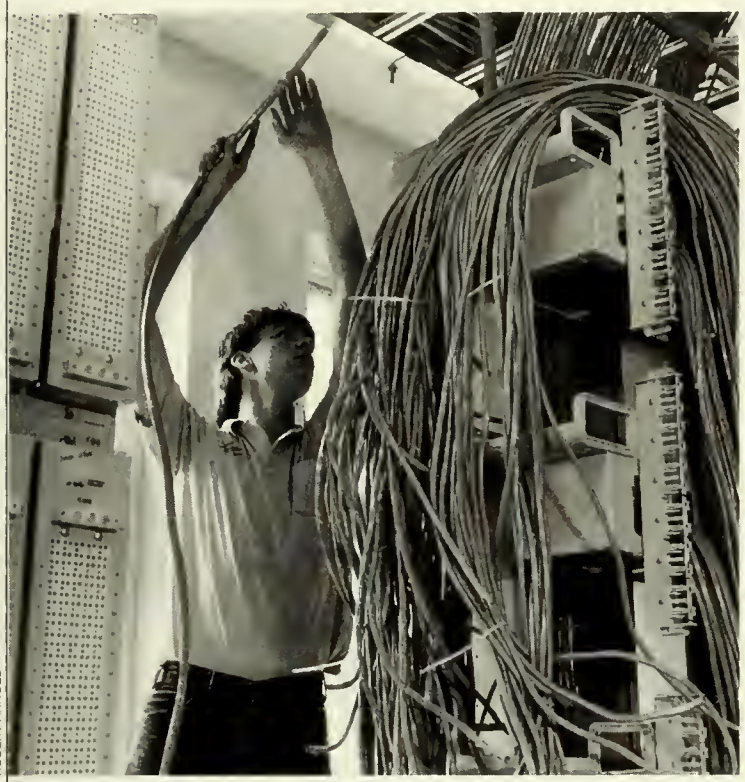
These and many other physical and programmatic changes and improvements over the past nine years have been made possible by a significant growth in the Institute's annual bounty of financial support. During the Strauss presidency, the yearly value of cash, gifts-in-kind and pledges received by WPI tripled, to $18.3 million. A significant factor in that growth was the highly successful Campaign for Excellence, which sought to raise $52.5 million (a goal that seemed unattainable to many) and instead brought in $63.7 million in gifts and pledges by its conclusion in late 1990.

Gifts of endowed funds and prudent investments helped double the market value of WPI's endowment to $126.5 million. Income from the endowment, in turn, has helped offset some of the costs of operating the university (as well as supporting scholarships, fellowships and

professorships). And, gifts received during the campaign and since have helped transform the campus by supporting a host of renovation and construction projects.

Among the most visible of these is the George F. Fuller Laboratories, a magnificent home for the information sciences at WPI, which was completed in 1990. Fuller was the capstone of a comprehensive campaign to improve the Institute's computing capabilities over the past decade.

Through gifts, discounts, special licensing arrangements and direct purchases, WPI and its departments



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have made hundreds of personal computers and high-power workstations available to students in general-access labs, have placed state-of-the-art computing machines on the desks and in the labs of faculty members, have upgraded the academic and administrative computing facilities (more than once), and have acquired a wealth of educational, research, statistics, and administrative software. Starting with a major construction project in 1989, the Institute has also linked all of these machines to each other—and to the rest of the world—with a high-speed campus network.

Other major construction projects completed in the last decade include the restoration of Alden Memorial, which in 1992 was reborn as a home for the performing arts; the construction of the Fitness Center in Alumni Gym; the transformation of the Pub in the basement of Sanford Riley into Gompei's Place, a pizzeria and deli; and the conversion of the former home of the Lambda Chi Alpha fraternity into Institute Hall, a small student residence. Beyond enhancing its existing campus, WPI has succeeded in expanding its grounds over the last decade through the purchase of numerous nearby properties, many of which now house WPI administrative offices.

Along with the growth of scholarship, resources and facilities has come increased recognition, much as Strauss predicted in his inaugural message. For the most part, WPI's rising profile is difficult to quantify, but positive indicators include its success in recruiting students from cities and towns well removed from New England and considerable anecdotal evidence that the name WPI is now far less likely to be greeted with puzzled looks beyond our own backyard.

Perhaps the most concrete gauge of the Institute's enhanced reputation has been its consistently high ranking in the annual review of colleges by *U.S. News and World Report*, which placed WPI first in the North among regional universities four of the last five years.

This year, WPI was moved into the far more competitive group of national universities (along with the likes of Harvard, Princeton and Yale), a reflection of its reclassification as a Doctoral II University by the Carnegie Foundation for the Advancement of Teaching. While the Institute lost its No. 1 ranking, the change, triggered by the growth in the WPI graduate program, only served as further recognition of the progress WPI has made in scholarship and research.

These and WPI's many other accomplishments have been enumerated in Strauss' nine annual report messages. More than a simple recounting of events and activities, these messages have formed a continuing chronicle of WPI's efforts to develop a comprehensive strategic plan for its future.

"The concern for planning and the need for institutional plans have become more and more important in higher education, as they have in all forms of human endeavor," Strauss says. "But it is also the case that planning is a very strong part of my own career expectations and of my own approach to management."

The process of shaping a plan for WPI began in 1985 when Strauss asked each of the Institute's academic and administrative departments to develop plans incorporating their goals and objectives for the next five years. These plans, in turn, helped establish the goals for the Campaign for Excellence and set the stage for the development of overall institutional objectives.

The next step on the journey to a strategic plan was the development, in 1985-86, of a concise institutional mission statement by the Board of Trustees, and the passage, in 1986-87, of a statement on institutional goals by the faculty. In 1988-89, Strauss appointed three study

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MICHAEL CARROLL

Three Thousand, Three Hundred and Seventy-nine Days at One Drury Lane

By Jean Strauss

The first time I saw One Drury Lane was from the back of a tandem bike as Jon and I peddled into Worcester on the last day of June 1985. I was 30 years old and we'd been married for just 16 days. While Jon was supremely qualified to become WPI's 13th president, being the wife of a college president was a position for which I had no resumé. At that moment, from my vantage point on the rear seat of the tandem, both the house and the role I was soon to play seemed enormous—unfillable.

In those first months and years, I'm sure I committed many a faux pas. Fortunately, there were lots of wonderful people encouraging me to just be myself. They never made me feel uncomfortable when life at One Drury Lane took whimsical turns.

Lately, I've grown quite nostalgic about what living in Worcester meant to us. You can't live in one place for almost a decade and not go through monumental changes. During our first year in Worcester a freshman mistook me for a student and asked me out. More recently, at Commencement, parents would ask me if I had a son or a daughter graduating. So I know that I at least look different.

There are a thousand memories we will take with us of our days within the walls of One Drury Lane. And there were numerous lessons I learned during my time at WPI that will guide me in the future. For example:

Rule No. 1: *Never Hold a Glass of Water When You Welcome Visitors*

The first time Don Berth '57, then vice president for university relations, came by the house, I was a bit nervous. Hoping to make a good impression, I exuberantly told him how glad I was to welcome him to One Drury Lane. To my horror, I realized that I'd accidentally spilled the glass of water I was holding all over Don's shirt and tie. I can still see the incredulous look on his face. To his credit, Don still visited us frequently over the years, though he always seemed wary around me if I had anything in my hands.

Rule No.2: *Never a Borrower Be*

For the first faculty wives tea I hosted, I borrowed a neighbor's silver tea service. This neighbor was wonderfully generous, but she neglected to tell me that the ornate ball on top of the teapot had broken off and had been temporarily reattached with a small wad of bubble gum. As I poured the first cup of tea for one of my guests, the ball fell off and landed right in her cup, trailing a stringy glob of gum. Without cracking a smile, she said, "I think I would prefer coffee."

Rule No. 3: *Always Check the Flue*

The reception for the first Presidential Founder's Dinner (for donors of at least $100,000) was held at One Drury Lane. A blizzard was raging outside, so five minutes before guests were to arrive I decided to light the logs in the fireplace to create a nice, warm, homey feel. Never thought to check the flue.

Pine boughs make a fast fire—and a lot of smoke. Within seconds, every fire alarm in the house sounded. It was quite a scene as people ran around opening windows, trying to fan out the smoke with copies of *National Geographic*, while Jon took the batteries out of the alarms.

Fortunately, because of the storm, our first guest was late. She arrived moments after we'd closed the last window. "What a lovely smokey smell. This place is so warm and homey," she said as she walked in.

Rule No. 4: *Always Check Under the Hood*

A young cat was hanging around the neighborhood one February. To get warm, it climbed onto the engine block of an Alpha Tau Omega fraternity member's car, which was parked in the driveway of One Drury Lane. When the student started the car, he heard a yowl. Opening the hood, he discovered that the poor animal had been severely injured by the fanbelt. "I've killed President Strauss' cat! Now I'll never graduate!" he thought as he raced off to a vet, who managed to stitch up the cat for a sizeable fee.

Relieved, the student arrived on our doorstep that night with the cat wrapped in a blanket. When Jon answered the door, the student blurted out nonstop what had happened, finishing with, "...and don't worry, the vet says your cat will be okay." Finally able to get a word in, Jon shrugged and said, "But that isn't my cat." The story has a happy ending. Jon, an old ATO himself, took the stray in. We named it Fanbelt.

Rule No 5: *Tenure Has Advantages, Even for College Presidents*

When our chocolate Labrador Retriever, Gracie, had 12 puppies (by our German Short-Haired Pointer, George), I was concerned that we wouldn't be able to find homes for such a large litter. I'm not as imaginative as Jon.

At the weekly faculty dinners we hosted, Jon would bring a couple of the tiny pups up to the dining room and pass them around the table. In less than a month we'd found homes for the whole lot. Interestingly, most of Gracie's pups went to faculty members who had not yet received tenure. (It's probably just a coincidence that everyone who took a pup ultimately did!)

Rule No. 6: *Never Gloat*

One fall I had several trustee wives to One Drury Lane for a luncheon. During the meal, we got into a discussion about the differences between men and women—particularly about how mothers are more instinctively attentive to the needs of their children than are fathers. To illustrate, I related a recent incident.

Jon was watching our son Kristoffer, who was then a toddler. Engrossed in the newspaper, Jon lost track of Kristoffer's whereabouts. After searching the house, he finally found him in the master bath—seated inside the toilet, happily splashing water as if he were in a wading pool. I said, rather emphatically, that that would *never* have occurred on my watch, and everyone nodded in agreement.

Two of the wives asked if they could come back later to see Kristoffer, who had been napping. I was just finishing getting dressed for the trustee dinner when the doorbell rang. As I hurried downstairs, I realized I had no idea where Kristoffer was. As I approached the door, I saw him—inside the downstairs bathroom, sitting in the toilet, happily splashing. Sheepishly, I answered the door with a wet kid in my hands. I've yet to live that one down.

Rule No. 7: *Always Use Water* and *Soap to Remove Food Coloring*

One afternoon, our son Jonathon had his new friend from pre-school over to play. The boy's name was Gabriel, and he had beautiful blond hair. After the kids had enjoyed themselves for a couple of hours, Gabriel's mom called to say she'd be over soon to pick him up. I was in the laundry room when Jonathon tapped on the door. "Hey Mom! Come see what we did!"

He led me by the hand to the living room. Everything was fine, except that most of Gabriel's hair was a deep forest green. "It works!" Kristoffer said, proudly holding up the bottle of green food coloring that came with his chemistry set.

I didn't know Gabriel's mom all that well, so I wasn't sure how she'd feel about her son coming home with a new hair color. We raced to the kitchen sink and I tried to wash the dye out with water. That only made it worse. Jonathon kept his head. "Here, Mom," he said, handing me a bottle. "Try soap."

It worked—sort of. At least it wasn't *as* green when Gabriel's mom arrived. The next day she told me that at bedtime that night, Gabriel's father had asked him if he'd been upset when Kristoffer and Jonathon dyed his hair. Gabriel nodded vigorously; "I wanted it to be orange," he said.

Jon and I spent exactly three thousand, three hundred and seventy-nine days in One Drury Lane. It doesn't seem so long unless I think about all the events that occurred. My mother died. Both of my sons were born. I found my birth family and wrote a book about the experience. Our kids learned to walk, then to talk, then to draw hieroglyphics on the walls with crayons.

We made some wonderful friends during our time in Worcester, and shared in many happy occasions—and some sad ones. We will not forget our days (or these friendships) now that we've moved on to a new adventure. It was a privilege being a resident of One Drury Lane. I grew to care about WPI the way I do about my own alma mater.

Nine years ago, when we first arrived, One Drury Lane seemed huge and unfillable. As we spent several weeks packing up our belongings, I knew we had managed to at least fill the house—and our hearts.

The Quest to Decentralize

Prior to accepting the post of WPI president, Jon Strauss served as vice president for budget and finance at the University of Pennsylvania and senior vice president for administration at the University of Southern California. In both jobs, he had great success with a decentralized approach to management and budgeting, wherein academic departments are given greater responsibility for creating their own budgets and for generating the revenues to support their activities.

"The major emphasis of my work in higher education...has been on bringing the faculty closer to the management issues and helping them understand and become more active in resource generation," Strauss told the *WPI Journal* in his first interview as WPI president in 1985. "While I am interested in faculty participation in more responsible and effective use of resources, my major interest is in faculty involvement in resource development."

His hope was to institute a similar system at WPI. How did that process go? Here is his assessment:

"We developed some rich databases on how we earn and how we spend our revenues on a decentralized basis, but we have not moved from the analysis to the synthesis. We have not made our departments responsible for earning the revenues to cover their program costs. In part that reflects the character of what historically has been a small college, now maturing as a medium-size university. And in part that reflects all the other things that have been on our plate.

"These have been tempestuous budgetary times and there are only so many things you can change at once. But we do have the data on a decentralized basis that we have used in the budgeting process and that people are using to understand how we do our business. I'd recommend continuing to develop the data and using it in our decision making, because the more years you have of the data the more valuable it is and the more trends you can see."

(Continued from Page 11)

groups made up of trustees, faculty and staff members, and students to look at the challenges the Institute faced in the areas of enrollment, student life and academic programs.

The study groups reached two fundamental conclusions. First, they said it was imperative that WPI be recognized nationally for the quality of its educational programs and research. And second, they noted that the WPI Plan, the foundation of the successes the Institute had realized for more than two decades, was the still the best vehicle for future excellence. They recommended that the Plan be enhanced and that the spirit behind it be revitalized and infused into all aspects of WPI.

This phase in WPI's strategic planning produced the recommendation that WPI establish several multidisciplinary research centers; develop new, nontechnical majors to take advantage of growing student interest in fields like management, the humanities and the social sciences; commission a comprehensive study of WPI's space utilization needs, including the need for a campus center; and seek to broaden the diversity of the faculty, staff and student body. The Applied Bioengineering and Intelligent Processing of Materials centers were established and the space study was undertaken; the remaining recommendations became the focus of later planning.

In 1990, five years of planning crystallized in a formal strategic plan, which was approved by the Board of Trustees that spring. The plan had six goals: enhancing the level of excellence in undergraduate education; enhancing the level of excellence in graduate education; increasing the quality and quantity of research and its recognition; enhancing the quality of life on campus; meeting the needs of professionals for continuing education; and strengthening WPI's external relationships.

In the months that followed, WPI's future direction was sharpened by the work of the Marketing Task Force, which looked for ways to increase the yield of students who could afford to pay WPI's full tuition, and the Commission on Residential and Social Life, which, among other recommendations, strongly urged the Institute to begin planning for a campus center and argued for the importance of community at WPI, which it said was WPI's third tower, joining learning and skilled arts. In response to a commission recommendation, Strauss created the Community Council to foster the spirit of community on campus.

In 1990-91, WPI took some time away from pondering its future to take stock of its strengths and weaknesses. The motivation was the 10-year review by the New England Association of Schools and Colleges, which accredits WPI's educational program. Many faculty and staff members spent a good part of the year preparing the materials NEASC would need to complete its review, including special self-studies on the freshman-year learning experience, intellectual and community culture, and the role of assessment at WPI.

As expected, WPI was reaccredited for another 10 years, with high praise for the excellence of the undergraduate program, the creativity and loyalty of the faculty and staff, the Institute's emphasis on research and scholarship, its established culture of balanced budgets, and

NEIL NORUM

From left, students in a recent Strive summer program, part of WPI's efforts to increase its diversity; a student project team in London, one of numerous places around the world students can now complete projects; a materials testing laboratory, important to a multidisciplinary research center in intelligent materials processing.

perhaps most important, the unique "colleagueship" between students and faculty. The association also pointed out a few areas where WPI had fallen short of his goals. One of the most important was the need to increase the diversity of its faculty, staff and student body.

As they have for most educational institutions that concentrate on technical disciplines, enrolling more women and more students of color, and increasing the diversity of its faculty and staff, have been especially daunting challenges for WPI. For a variety of reasons, women and minorities have always been underrepre-

JANET WOODCOCK

sented in engineering and science. Reversing that trend takes creativity and hard work.

WPI has made progress. More focused equal opportunity hiring practices have helped boost the diversity of the staff and administration. New admissions programs aimed at reaching out to women applicants, combined with the growing number of women faculty members, have helped increase the representation of female students in the undergraduate population to about 20 percent, from about 15 percent nine years ago. And students of color now make up 4.5 percent of freshmen and sophomores, triple the percentage of nine years ago.

Contributing to that last accomplishment have been a variety of programs launched over the past decade. These have included COMET, a program supported by GTE Corp. and the Massachusetts Board of Regents that helped prepare students of color in Worcester for academic programs in science and technology, the School/College Collaborative, which has sought to increase the quantity and quality of science and technology education in the public schools, and the General Electric Foundation Scholarships, which provide awards to underrepresented minority students based on academic achievement and financial need.

In 1991 United Technologies Corp. awarded WPI a five-year, $500,000 grant to support its efforts to increase diversity and pluralism. The award funded the creation of the Office of Multicultural Affairs and the development of Strive for College and Careers in Mathematics, Engineering and Science. Strive provides enrichment and support for academically talented high school juniors from underrepresented minorities interested in careers in science and mathematics. Its centerpiece is a four-week summer program on campus that introduces students to the excitement of scientific investigation.

Augmenting efforts to enroll greater numbers of students from underrepresented minorities have been programs aimed at helping to support and retain these students. These include the new Office of Minority Student Affairs and EMSEP (Excellence in Mathematics, Science and Engineering Program). The latter includes a special new-student orientation, support programs, and an early intervention program.

In addition to helping open the door to a WPI education to a broader group of students, the Institute also devoted considerable effort and thought over the past nine years to improving the quality of that education. In part, this has meant "fine-tuning" the experience students gain from the WPI Plan, the innovative, project-driven educational program approved by the WPI faculty nearly 25 years ago. The fine-tuning included the adoption of distribution requirements by all academic majors and the elimination of the all-or-nothing Competency Exam, one of the Plan's four original degree requirements.

Among the most significant enhancements to the Plan over the past decade has been the enormous growth in opportunities for off-campus project work. In 1987 the London Project Center, modeled after the Institute's first off-campus residential center in Washington, D.C., was inaugurated. Since then, project centers and programs have been established in more than 15 countries on five continents.

In 1991, these programs, along with on-campus initiatives like the Center for International Studies, were brought together under the umbrella of the Global Perspectives Program, which seeks to give all WPI students a better understanding of and appreciation for other cultures and other ways of doing business—qualities increasingly valued by business and industry. The International Scholars Program was also created to recognize, with a designation on their transcripts, students who make global studies a substantial part of their academic careers.

By the time the Institute adopted its overall strategic plan, a variety of trends were already conspiring to make its objectives and strategies almost obsolete. In particular, shrinking high school graduating classes and declining interest among young people in science and engineering were making the process of filling WPI's entering classes more and more challenging.

WPI's efforts in recent years to cast its admissions net well beyond its traditional recruiting region and the continuing attractiveness of the WPI Plan helped the Institute continue to meet its enrollment targets. (In fact, it

increased undergraduate and full-time graduate enrollment during a time when many of its competitors were seeing their classes shrink.) But it accomplished this feat by admitting an ever greater percentage of its applicant pool.

Perhaps more important, the ability of WPI's students to pay its tuition declined steadily in the late 1980s and early 1990s, just as the federal and state governments were cutting back on their grant and loan programs. As a result, an ever growing percentage of WPI undergraduates have required financial assistance, placing a greater and greater burden on the operating budget.

"In a five- to six-year period, our institutional aid as a percentage of tuition went from 10 percent to 30 percent," Strauss says. "Nothing else in this world changes that rapidly. That's been especially challenging at an institution like ours with enormous fixed costs and longtime commitments to people and programs."

To respond to these challenges, President Strauss in 1992 appointed the Blue Ribbon Task Force. The group's overriding objective was to fashion a new plan for the coming decade. In its final report, prepared for the Board of Trustees in May 1993, the task force made a number of recommendations organized into the broad categories of academic program, quality of life and financial equilibrium.

In addition to echoing previous calls for a campus center and urging continuing development of the Global Perspectives Program, the task force called for the creation of interface disciplines, academic programs that cross WPI's traditional disciplinary boundaries and that might appeal to "humanists who need to function in a technological world." It was also suggested that the Institute hire a marketing firm, Barton Gillet, to determine, among other things, the potential demand for these and other new programs.

In the following months, the task force's report, combined with the study by Barton Gillet, became the launching pad for *The New WPI*. In the months ahead, as WPI continues its quest for the new ideas, the new directions, and the new approaches that will keep it strong, continue to build its reputation and its appeal to new generations of students, hone its mission, and bolster the excellence of its programs, Strauss says it is his hope that the Institute will not lose the sense of urgency that has kept it working toward a workable plan for the future.

"Our own success in the short term has been an issue for WPI," he says. "We've made our enrollment targets. We've met our budget targets. We've done so by expecting our faculty and staff to perform and work much harder, and they have. We have this record of success, and yet we're being a contrarian.

"We've been fortunate, but the risk increases every year. Can we continue to maintain enrollment while everyone else is losing theirs? We hope so, but it could catch up with us. The impetus is increasing. You'd hate to do the right thing for the wrong reason."

As he prepared to assume his new post, Strauss said he will miss having the ability to influence the future "of a very important institution. Certainly, I'll miss the interactions I've had with students, because I will not have that in my new role. I will not miss always having to be conscious of being the figurehead. It will be nice to lead a more normal family life that doesn't always revolve around being the president of WPI.

"Most of all, Jean and I will miss the interactions we have had with the people of WPI. This has truly been one of the most extraordinary experiences of our lives. I am very proud to have been the 13th president of WPI, and even more proud of the hard work and enthusiasm of the WPI community that made possible the successes of the last nine years."

Building a Board

When asked for his list of the most significant achievements of his nine years in office—the ones that will have the most enduring benefits for WPI—Jon Strauss places the growth and development of the Board of Trustees close to the top.

"The board is more than 80 percent different than it was nine years ago," he says. "That wasn't an accident. I've put a lot of effort into board recruitment and board development, and by many measures we have one of the most distinguished boards in the country. Even if you compare us to institutions with which we would not normally be compared, on a board-to-board basis, we will equal or excel almost any cohort of institutions. That's exciting, and it will pay enormous dividends to this institution moving forward."

FINANCIAL SUMMARY

By Robert W. Gailey
Vice President for Business Affairs
and Treasurer

WPI's overall financial position at June 30, 1994, continues to be strong. The Institute's investments and fund balances are at an all-time high. The Endowment Fund realized an increase in book value of $2.4 million for the year. Although WPI enjoys the flexibility of having 54 percent of its endowment restricted by the Board of Trustees, a low debt to total endowment ratio and a healthy total endowment per student ratio, WPI's growing tuition dependence, and its relatively high and growing financial aid burden will provide a challenge to the operating budgets in the years ahead.

Total assets increased by approximately $16 million, or 7.6 percent, to $227 million, while total liabilities increased by $6.2 million. Debt service (principal and interest) represented 5.2 percent of unrestricted current fund expenditures and mandatory transfers for the fiscal year. Investment in property, plant and equipment (less accumulated depreciation) increased by 14.3 percent to $59.2 million.

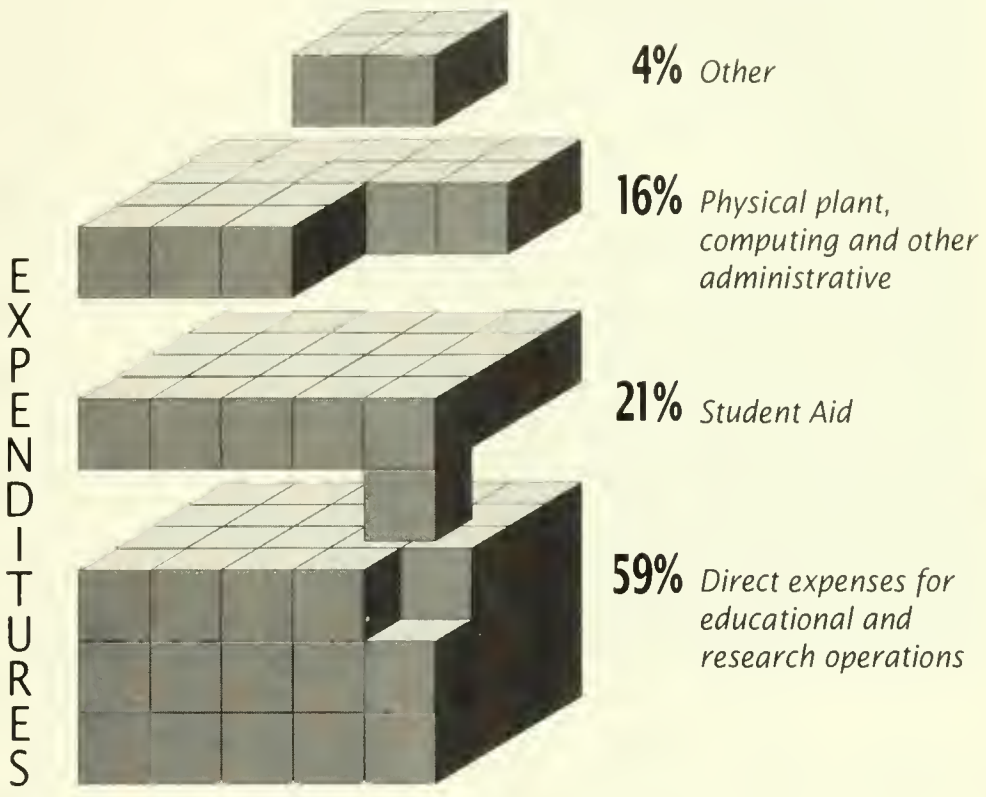
The market value of the Endowment Fund was $126,518,000 as of June 30, 1994. Although the fund's 4 percent total return was the lowest in several years, it exceeded the 3.2 percent benchmark established by the trustee Investment Committee. The total return compared favorably with the Standard and Poor's stock index gain of 1.4 percent and the Shearson Lehman intermediate bond index gain of -0.2 percent.

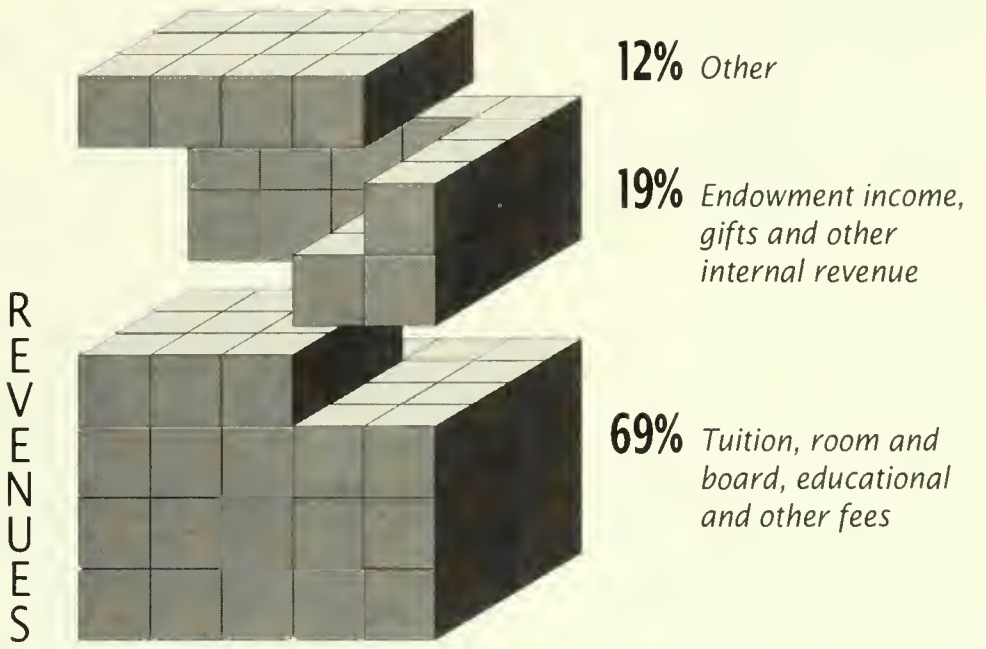
Total Current Fund revenue increased by $3.3 million in fiscal year 1994 to a total of $81.4 million; this represented a gain of 4.2 percent over fiscal year 1993. There was a small positive bottom line from operations for the fiscal year of $10,392, but the Institute increased its overall fiscal position (total fund balance) by $9.9 million, a 5.8 percent gain for the year.

Total funds expended for instruction and department research increased slightly to 34.6 percent of unrestricted educational, general and auxiliary revenue. While the annual funds expended for operations and maintenance of the physical plant increased slightly, accumulated deferred maintenance on the WPI campus continued to total about $15 million.

Student aid awarded from unrestricted current funds increased by 13.6 percent to more than $11.5 million; it represented 24.4 percent of the total revenue (including room and board) collected from undergraduate students and 27.7 percent of undergraduate tuition (discount rate).

While auxiliary operations (housing, food service, bookstore, etc.) generated $7.3 million in revenue, the cost to generate that resource ran slightly lower. The Institute's policy of operating auxiliary services on a self-supporting basis was maintained.





FINANCIAL HIGHLIGHTS

YEARS ENDED JUNE 30, 1994 AND 1993

1. General Operating Funds *(Thousands of Dollars)*	1994	1993	Percent Change
Tuition, fees and other educational revenues	$48,837	$46,311	+5.5%
Student financial aid	17,285	15,885	+8.8
Gifts, grants and bequests, as recognized	8,237	8,193	+0.5
Revenues from sponsored research programs	9,320	9,109	+2.3
Total staff benefit expenses, before allocation	7,351	6,930	+6.1

2. Endowment and Similar Funds *(Thousands of Dollars)*	1994	1993	Percent Change
Beginning market values	$127,898	$114,757	+11.5%
plus:			
Investment results			
Income (interest and dividends)	$4,075	$5,013	
Realized gains	1,855	8,754	
Change in unrealized gains	(2,907)	3,636	
Total investment results	$3,023	$17,403	-82.6
less:			
Used in support of college	(4,178)	(3,996)	+4.6
Transferred to restricted funds	(1,717)	(266)	+545.5
Net reinvested in endowment	(2,872)	13,141	
plus:			
Additions to endowments, mostly from gifts	2,574	4,389	-41.4
Ending Market Value	$127,600	$127,898	-0.2

Five-Year Summary of Total Return Data	'94	'93	'92	'91	'90
WPI Total Return	4.0%	11.9%	12.4%	8.5%	5.0%
WPI Policy Index	3.2	13.5	13.5	8.7	13.7
S&P 500	1.4	13.6	13.5	7.4	16.4
Shearson Lehman Int. Bond	-0.2	10.5	13.2	10.5	7.8
CPI Index	2.5	3.0	2.8	5.1	4.8

Copies of the complete audited financial reports for Worcester Polytechnic Institute for fiscal year 1994 can be obtained by writing to:

Office of Business Affairs
Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609-2280

The Year That Was...

A Look Back at the Major Events of 1993-94

By Jon C. Strauss

Some of the many accomplishments at WPI during the 1993-94 fiscal year are highlighted below against the six goals of the Strategic Plan.

Goal 1: ***Enhance the Level of Excellence in Undergraduate Education***

- WPI's highly successful Global Perspectives Program continued to expose students to other cultures through on-campus programs and project and course work abroad. A total of 209 students participated in off-campus projects in 1993-94, up 33 percent from 1992-93.
- The Massachusetts Academy of Mathematics and Science continued WPI's commitment to improving pre-college science and mathematics education. Seventy-six outstanding high school juniors and seniors from Central Massachusetts were involved in the second year of this pioneering program of excellence sponsored by the Commonwealth of Massachusetts. All 31 of the graduating seniors are attending prestigious universities, including 14 who are enrolled at WPI.
- The combined B.S./D.V.M. program, run in conjunction with the Tufts University School of Veterinary Medicine, yielded 13 new students for 1994-95. This program enables a student to earn admission to both WPI and Tufts while still a senior in high school.
- A major grant from the Davis Educational Foundation continued to support educational initiatives in the departments of Biology and Biotechnology, Chemical Engineering, Civil Engineering, Computer Science, Mathematical Sciences, and Mechanical Engineering. These initiatives introduce the active, collaborative learning typical of the WPI Plan projects into first- and second-year courses in a cost-effective manner.
- The new Entrepreneurs Collaborative, modeled on the highly successful International Scholars Program, began this year. Donald F. Berth '57, former vice president for university relations, and Professor Arthur Gerstenfeld are leading a group of faculty members, students and alumni seeking to learn the skills of entrepreneurship.
- The Class of 1998 was on track to exceed our goal of 650 freshmen by at least 40. Of the more than 715 paid deposits received by the spring deadline, 21 percent were from women and 4.5 percent were from students of color. Some 74 percent of these students were in the top quintile of their high school classes; their median verbal and math SAT scores are 530 and 650, respectively.

That's the good news. The bad news is that there was an 8 percent drop in applications last year; in order to achieve this fine class we accepted 86 percent of our applicants. This is a clear indication of the high degree of competitiveness among technological universities today.

Our expenditures for undergraduate financial aid in 1994-95 should be right on our $12 million budget for a tuition discount of 29 percent (it was 28 percent last

Two examples from the growing Global Perspectives Program: Above, Corinne Kachler '96, Michael Conklin '96, Kimberley Scofield '96 and Antonio Delgado '96, who completed a project in San Candido, Italy, last summer. Left, Ahmed Al-Baiti '95 (second from left) and William Herron '96 (far right), who studied biogas generators in Botswana.

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year). The drop in applications and the increase in tuition discount argue strongly for broadening WPI's programs as well as our appeal to prospective students as was advocated by the Blue Ribbon Task Force and outlined in *The New WPI* proposal (see page 2).

- In response to a challenge from the Blue Ribbon Task Force, more than 50 faculty members working in teams produced 18 proposals for the development of new programs in what we are calling interface disciplines. The objective is to broaden WPI's appeal to students who would not normally consider an engineering school and strengthen our program offerings in areas of high societal demand. An ad hoc committee of faculty governance chaired by Professor George Phillies recommended seed funding for the best of these proposals starting in the summer of 1994.
- Following up on work on the freshman year learning experience completed as part of WPI's 1991 regional accreditation by the New England Association of Schools and Colleges, a group of faculty and staff members organized a three-day Future Search Conference in June for over 60 of their colleagues. Their objective was to bring the excitement of project-based learning, characteristic of the upper-class years at WPI, to the freshman year.

Goal 2: *Enhance the Level of Excellence in Graduate Education*

- WPI awarded 17 Ph.D.s at Commencement on May 21, 1994. While this total fell short of 1993's record of 28, it contributed to an impressive four-year running average of doctorates awarded, which has risen from seven to 20 over the last 10 years. This is a strong testament to the improving quality and quantity of faculty scholarship at WPI.
- In view of our success in awarding Ph.D.s, the Carnegie Foundation for the Advancement of Teaching this year reclassified WPI from a Comprehensive University to a Doctoral II University.
- During the past year, the Management Department and the Fire Protection Engineering Program delivered distance learning programs to remote sites through the use of two-way compressed video equipment made by PictureTel Corp. This equipment is maintained by the Instructional Media Center for use by the WPI community.
- The University Relations Office was particularly successful this past year in securing industrial support for graduate fellow-

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Above, Judith Nitsch '75, founder of her own engineering firm, speaks at a seminar offered by the Entrepreneurs Collaborative. Left, Michael Ferraris '95, left, works with math students in a program in cooperative learning sponsored by the Davis Foundation.

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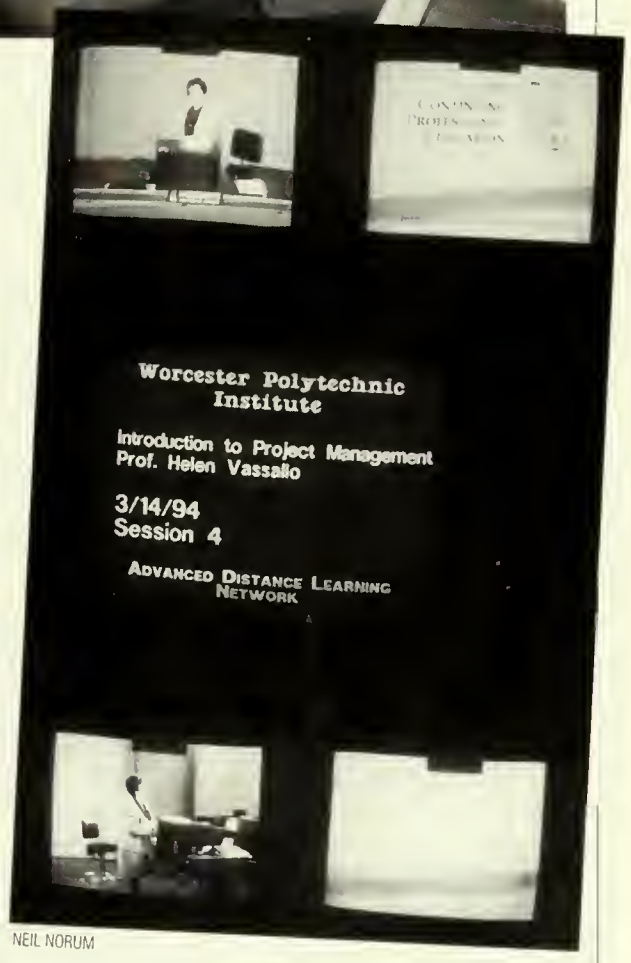
MICHAEL OORSEY



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Clockwise from top, associate professor Yitzhak Mendelson (pointing), teaches an introductory course in biomedical engineering, part of a new interface discipline in pre-health studies; views of a distance learning program in management; a scene from a summer conference on the freshman experience at WPI.

ships. The 13 fellowships now in place provide an excellent foundation for communication, collaboration, and it is hoped, future support.

Goal 3: ***Increase the Quality and Quantity of Research and its Recognition***

- Twelve-month research support through June 1994 totaled $7.1 million, an increase of 25.6 percent from the previous period. (This does not include $5 million in funding for the Center for High Performance Computing, $800,000 in NSF support for the renovation of Higgins Laboratories, and more than $1 million in gifts designated to support research.)
- The Carl Gunnard Johnson Powder Metallurgy Center received national recognition and support from the Alfred P. Sloan Foundation and eight corporations. This multidisciplinary initiative is the result of a collaboration of faculty members from the manufacturing, materials and management programs.
- The Aluminum Casting Research Laboratory was awarded a $1.4 million, five-year contract from the U.S. Department of Energy as part of its Metals Initiative Program.
- In the Electrical and Computer Engineering Department, Professors David Cyganski, Richard Vaz and John Orr were awarded $900,000 over three years by the

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Top, from left, professors David Cyganski, Richard Vaz and John Orr with the products of their work on model-based object recognition. Bottom, NSF Young Investigator Grover Swartzlander.

Advanced Research Projects Agency (ARPA) for research on model-based object recognition.

- Three of the initial 140 awards from the federal Technology Reinvestment Program supported consortia lead by WPI: the Realization Manufacturing Coalition, the Central Massachusetts Manufacturing Partnership, and the Massachusetts Bioengineering Center.
- Professor Grover A. Swartzlander Jr., new last year in physics, was named an NSF Young Investigator with as much as $500,000 in support over the next five years.

Goal 4: *Enhance the Quality of Life on Campus*

DIVERSITY

- Four students from the second class of WPI's summer program for minorities, Strive for College and Careers in Mathematics, Engineering and Science, matriculated as members of the Institute's Class of 1998.
- The Office of Human Resources strengthened WPI's affirmative action hiring procedures this past year. Now the hiring pools for all jobs with underutilization of women or minorities will include suitable candidates from whom an affirmative selection will be made.
- Under the leadership of Blanche Pringle, the new Director of Minority Student Affairs, the first year of Excellence in Mathematics, Science and Engineering Program (EMSEP), our new minority orientation and advising program, proved an extraordinary success. Twenty-five of the 27 participants will continue in 1994-95 with excellent reports of progress and performance.
- A two-day Search Conference on Community and Pluralism was held on campus in January with the active participation of more than 70 faculty and staff members, students, alumni, trustees, and neighbors. The resulting Pluralism Advancement Model, which includes specific tasks and timetables to improve pluralism at WPI, will be managed by the Community Council in 1994-95.
- A well-attended conference in April celebrated the 25th anniversary of the admission of women undergraduates at WPI. Jane Shaw, president and COO of Alza Corp. and a 1992 recipient of an honorary degree from WPI, gave the keynote address.

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Above, from left, Holly Keyes Ault '74, Susan Daly '94, Karen Daly '94 and Patricia Graham Flaherty '75, participants in a celebration of 25 years of women undergraduates at WPI. Right, the men's soccer team in action.

COMMUNITY LIFE

- Dean of Students Janet Richardson led a community-wide effort to define the program for the planned campus center. With a program in place, nearly $2.5 million raised for the building, and good prospects for significant additional fundraising, ground breaking for this facility, so important to enhancing the quality of life on campus, could well occur within the next two years.
- The first year of our new Healthy Alternatives Program was a resounding success. This program, sponsored by FIPSE and led by Mary Cox, started several initiatives to educate students about the effects of alcohol and other drugs and sponsored social and athletic programs to empower and support WPI students who choose to abstain.
- The Community Council championed the implementation of the recommendations of the Blue Ribbon Task Force while working to improve the sense of community on campus.
- Our NCAA Division III intercollegiate athletic program and our active club and intramural sports programs continued to enjoy high levels of participation and success. The wrestling team was the New England Division III champion, the varsity football team was the Freedom Conference champion, and the soccer team won the Constitution Athletic Conference championship. The women's tennis team was the MAIAW state champion and the women's field hockey team qualified for the ECAC tournament.
- After extensive study, the Parking Committee, chaired by Professor Ted Crusberg, found that the 796 official parking spaces on campus can accommodate the demand on all but the worst snow days, given active enforcement. It did point out, however, that such important new projects as the campus center, the proposed closing of West Street, and the "greening" of the Quadrangle (including the removal of the main faculty and staff parking lot), will surely require the addition of many new spaces. On our space-poor campus, that will most likely require the construction of at least one parking structure, albeit one that the WPI community would be loathe to support through parking charges.

PHYSICAL ENVIRONMENT

- The long awaited expansion and renovation of Higgins Laboratories, home of our premiere Mechanical Engineering Department, has begun. This $8.5 million project includes some 20,000 additional square feet of space, primarily in a new addition adjacent to Alumni Gymnasium, and the complete renovation of the original laboratories. The addition was scheduled for completion in the fall of 1994 with the total project to be completed by fall of 1995.

To date, some $7.5 million in funding has been identified for the project, including large gifts from the Alden, Keck, Lufkin and Stoddard Foundations, an award from the National Science Foundation, gifts from several individuals, and anniversary gifts from the Classes of 1943, 1944, 1954 and 1969. Lots of excellent naming opportunities remain for those who might be inclined to provide additional support for this important project.

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- The campus computer network was extended to all major residence halls during the summer of 1994. The expansion provided telephone, computer communications and cable television services to all rooms.
- Although it will little change the external appearance of the building, a planned $720,000 renovation of the heating and ventilation system in Goddard Hall will improve the safety and efficiency of this long-time home of the Chemistry and Chemical Engineering departments.
- A complete renovation of Freeman Plaza, which sits between Salisbury Laboratories, the Washburn Shops and Gordon Library, was recently completed. A new look for this important campus meeting place will set a new standard for our campus landscaping.
- Last fall, WPI acquired the Salisbury Estates, an apartment complex adjacent to the WPI campus. Presently operated as market-rate rental housing, this 108-unit complex, which sits on 6.5 acres adjoining Salisbury Pond, may become another student housing option in the future.

Goal 5: *Meet the Needs of Professionals for Continuing Education*

- Our new Nypro Leadership Institute, a week-long residency program for midlevel managers from the worldwide facilities of NYPRO Corp., has proven to be a great success. It is serving as a model for other such programs currently being designed by the Office of Continuing Education.
- The faculty approved a new certificate program that will recognize the completion of individually designed programs of graduate courses in computer science, engineering and mathematics.

Goal 6: *Strengthen WPI's External Relationships*

- Once again in 1993, WPI was ranked No. 1 among comprehensive institutions in the North by *U.S. News and World Report.* Interestingly, with its reclassification by the Carnegie Foundation to Doctoral University II, WPI will find itself competing with the likes of Harvard and Stanford in future *U.S. News* rankings. In this company, it will probably be a few years before WPI wins a No. 1 ranking again.
- The Presidential Founders, which honors alumni and friends with cumulative giving to WPI of at least $100,000, recognized 16 new members at the Founders Day Dinner on Nov. 11, 1993.
- The grand total of cash gifts ($11.4 million), gifts-in-kind ($3.4 million) and net new pledges ($3.5 million) for the 1993-94 fiscal year is $18.3 million. This exceeds last year's all-time record of $17.3 million.
- At a joint dinner in October 1993, members of the Board of Trustees and the Institute's departmental advisory committees heard trustee Leonard E. Redon '73, general manager and vice president for market development of Eastman Kodak's Imaging Group, speak on "A New Kodak." The seven advisory committees, made up of distinguished alumni and friends, have proved invaluable in providing advice, reviewing progress and developing support for WPI's ambitious plans—departmental and institutional.
- Seven new members were elected to the WPI Board of Trustees during 1994-95. George T. Abdow '53, chairman of Abdow's Big Boy Restaurants, was elected in October 1993 to complete the unexpired term of alumni trustee Arthur J. LoVetere '60. Claude-Alain Tardy, vice president and general manager of Norton Co., Thomas A. Corcoran, president of the Martin Marietta Electronics Group, and H. Kerner Smith II, president and CEO of Riley Consolidated Inc., were elected as term trustees in October 1993. Michael A. DiPierro '68, president of Baystone Corp., and Philip R. Morgan, president and CEO of Morgan Construction Co., were elected as alumni and term trustees respectively in May. John C.S. Fray, professor of cellular and molecular physiology at the University of Massachusetts Medical School, was elected a term trustee in June.

Of particular note is the fact that Philip Morgan is the fifth generation of Morgans to serve on WPI's board. His father, Paul S. Morgan, and his grandfather, Philip M. Morgan, both served as board chairman, and his great-great-grandfather, Charles H. Morgan, was a member of the founding board.

1993-94: A Year of Building

By Alfred R. Doig Jr., Vice President for University Relations

One of the joys of working in development is seeing concrete results from your work—sometimes quite literally. As I've walked across campus each morning over the past six months, I've watched with fascination as a three-story addition has risen beside Higgins Laboratories. Today the addition is nearly complete and its gleaming expanses of glass contrast stunningly with the handsome brick facade of this 52-year-old building.

The addition is just one phase of a comprehensive rebirth of Higgins, a process that will, a year from now, produce a modern home for mechanical engineering at WPI. This $8.5 million project is under way today thanks to the generous gifts we've received from many corporations, foundations and individuals. Prominent among these are $2.4 million from the George I. Alden Trust, $1.5 million from the Stoddard Trust, $500,000 from the Lufkin Trust, $425,000 from the W.M. Keck Foundation, $222,000 from Pauline W. Heald, $200,000 from Raymond J. Perreault '38, $150,000 from the Elsworth Foundation, $150,000 from Norton Co., and $75,000 from Mr. and Mrs. Milton Higgins.

In addition, the Classes of 1944, 1954 and 1969 dedicated the unrestricted portion of their anniversary class gifts—nearly $423,000—to the Higgins project and the National Science Foundation awarded the Mechanical Engineering Department $800,000 to help rejuvenate several of the building's research labs.

These and many other gifts and pledges have brought the total raised to more than $7.5 million, leaving about one million to go. It is gratifying to see that a substantial portion of the funding for the Higgins renovation and expansion has come from local sources: family foundations, corporations and individuals right here in the Worcester area. This hearkens back to the campaign that originally raised the funds to build Higgins, a drive in which many of these same families and corporations participated.

The start of the Higgins renovation was one of the highlights for WPI last year. In the development area, the highlight was the

The old and the new contrast in this view of the nearly complete 20,000-square-foot addition to the 52-year-old Higgins Laboratories.

$18,246,779 in cash, gifts-in-kind and pledges received by the Institute, a new all-time high. Of this total, $11,384,472 was in cash, $3,400,099 was in the form of gifts-in-kind, and $3,462,208 was in pledges. Included in that total is $2,245,084 in giving to the annual Alumni Fund, also a new all-time record total.

As the Institute looks ahead to its next major comprehensive fund-raising campaign, achievements like these bode well, indeed. The official announcement for the new campaign is still a year or more away, but already we are beginning to think about the programs and initiatives for which we will seek funding.

Before we can set these objectives, we must have a clear idea of the directions in which we want the Institute to move in the decade ahead. Then we must consider the strategic investments—new academic programs, improvements to the quality of life, physical plant changes or additions, and so on—that will be needed to create the momentum to move us in those directions. Those investments, in turn, will become the major goals of the campaign.

This planning process is already under way and will continue this year under the guidance of interim president John Lott Brown '46. But the final stages in the process must await the appointment, sometime next summer, of WPI's 14th president, who will be charged with the responsibility of leading the Institute through the campaign period.

Presidential leadership will play a vital role in the success of the upcoming campaign, much as it did during the highly successful Campaign for Excellence of 1985 to 1990. President Jon C. Strauss was instrumental in helping the Institute develop the objectives for that drive and, working with former vice president Don Berth '57, labored hard to be sure that the $52.5 million target was not only met, but exceeded. In the

Fiscal Year 1994 Fund-Raising Results

(in percent)

Cash Received *
$11,384,472

*Does not include gifts-in-kind

Total Activity
$18,246,779

process, he helped raise the Institute's fund-raising sights.

An important element in that sight-raising process was the creation of the Presidential Founders, a group of men, women and family foundations who have, since the Institute's creation, made cumulative gifts and pledges to WPI equaling or exceeding the $100,000 founding gift of John Boynton. During the Campaign for Excellence, gifts from the Presidential Founders accounted for half of all dollars raised.

In the years since the campaign, we've added 65 additional Presidential Founders, bringing the total to more than 200. Sixteen new members joined us for the annual Founders dinner in 1993, when the Institute honored Miriam Rutman and the late Walter Rutman '30. Another 16 new members came on board before the night of the 1994 dinner, at which the White family—Anne and Leonard '41 and Shirley and David '75—were recognized.

Clearly, support at the Presidential Founder level has made a tremendous difference to WPI as it has sought to become a stronger institution. But in reality, every gift to WPI counts. Every dollar we receive helps raise the Institute's level of excellence. And every thing we do to make this an even more outstanding institution adds to our growing recognition.

The quality and innovation of WPI's educational programs, the reputation and strength of our faculty, the record of achievement of our alumni—these are all good reasons to invest in the future of this institution. Another good reason is our sincere commitment to being a good steward of your investment.

Honored at this year's Presidential Founders dinner, David White '75 and his father, Leonard White '41, together run the R.H. White Construction Co.

Whether you make a gift of cash, a planned gift or a bequest; whether you make a gift of an endowed fund or a gift that will be put to immediate use; and whether you choose to restrict your gift to a particular purpose, such as financial aid, or let WPI determine where it can best be put to use, we will use your dollars wisely and make sure that they go as far as possible to support the goals and missions of the Institute.

You can also feel confident that you are investing in an institution that is financially sound. WPI recently compared its financial picture to those of 46 other colleges and universities that, like WPI, have received an A bond rating from Standard and Poor's. While the Institute has some areas of concern (for example, there is too little flexibility in its operating budget to respond to unforseen expenses), the picture on the whole is quite favorable.

For example, in the areas of debt to endowment ratio (a measure of relative debt load), endowment per student, the size of the quasi-endowment (unrestricted endowment funds), and the ratio of quasi-endowment to restricted endowment, WPI has performed better over the past three fiscal years than the median for the group of 46 institutions. In addition, WPI's relatively low level of deferred maintenance is laudable.

Our many generous donors do not make gifts to WPI simply because of our financial performance, of course. It is loyalty to this institution, a sincere belief in its mission and outcomes, and a desire to see it become an even better university in the years ahead that lie behind so many of the contributions we receive.

On behalf of the trustees, faculty, staff and students of WPI, I'd like to take this opportunity to applaud that vision and to thank everyone who has invested in WPI over the past fiscal year. On the pages that follow, you will find the names of many of these benefactors.

Giving to WPI: 1993-94

WPI gratefully acknowledges the support of the thousands of individuals, foundations and corporations whose contributions of $14,784,571 in cash and gifts-in-kind through the Alumni Fund, the Parents Fund, mini-campaigns and general development efforts during the 1993-94 fiscal year (July 1, 1993, to June 30, 1994) are already at work making WPI a stronger and more outstanding institution. Space does not permit the listing of all their names. An additional $3,462,208 was pledged during the fiscal year. These commitments will be listed in future reports as they are received as cash or gifts-in-kind.

$100,000 and above

George I. Alden Trust
Philip G. Atwood '37
Harry F. Chapell '54
China Technical Consultants Inc.
Davis Educational Foundation
Digital Equipment Corporation
Robert A. Foisie '56
George F. and Sybil H. Fuller Foundation
Estate of Edith B. Green '10
Caleb D. Hammond '37
Pauline W. Heald
Robert W. Hewey '40
Milton P. Higgins
William D. Holcomb '38
Howmet Turbine Components Corporation
W.M. Keck Foundation
Eugene V. Kosso '46
Richard A. Lufkin Trust
Commonwealth of Massachusetts
Paul M. Murphy '38
Douglas G. Noiles '44
Norton Company
Raymond J. Perreault '38
Alfred P. Sloan Foundation
Stedman W. Smith '36
Stoddard Charitable Trust
United Technologies Corporation
Viewlogic Systems Inc.
Howard C. Warren '42

$25,000 to $99,999

Walter L. Abel '39
Joyce G. Adderley
Herbert Asher '44
AT&T
Eleanor W. Bateman
Robert H. Beckett '57
John R. Brand '36
Allen Breed '46
Robert B. Davis '46
Dining and Kitchen Administration Inc.
Exxon Education Foundation
Fairlawn Foundation
Raymond J. Forkey '40
Hoche-Scofield Foundation
Richard T. Gates '52
General Electric Foundation
Raymond R. Hagglund '56
Hewlett-Packard Company
John E. Hossack '46
Mr. and Mrs. William Henry Hough
IBM Corporation
Rolf Jensen & Associates
Steven T. Kelley
Estate of Mary C. Knight '28
Luther C. Leavitt '34
William M. Lester '28
The Macamor Foundation
Thomas M. McCaw '46
Procter & Gamble Company
Mr. and Mrs. Richard Prouty
Elijah B. Romanoff '34
Texaco Inc.
Estate of William B. Wadsworth
WPI Alumni Association

$10,000 to $24,999

Allied-Signal Inc.
Carl W. Bettcher Jr. '41
Cushing C. Bozenhard '46
Edward S. Coe Jr. '31
Mary Jane Coe
Corning Inc.
GTE Corporation
Hartford Steam Boiler Inspection & Insurance Company
Charles R. Healy '56
Gerald F. Hickey '46
William H. Hills '54
Ingersoll-Rand Company
August C. Kellermann '46
Kemper National Insurance Companies
Paul N. Kokulis '45
Mrs. David A. Kuniholm '40
Estate of Richard Lamothe '61
John H. Lancaster '39
Gordon B. Lankton
Liberty Mutual Insurance Co.
Myles McDonough
Motorola Inc.
Pfizer Inc.
Raytheon Company
Schlumberger-Doll Research
Tarek M.A. Shawaf '55
John J. Shields '69
Raymond B. Shlora '40
William R. Steur '35
Harry W. Tenney Jr. '56
The Torrington Company
Xerox Corporation

$5,000 to $9,999

BASF Corporation
Edward C. Berndt Jr. '45
John E. Bigelow '44
Anna Harrington Boardman
John Lott Brown '46
Philip G. Buffinton '49
Central Sprinkler Company
CIGNA Corporation
Dr. and Mrs. Noel L. Cohen *p*
Daniel I. Coifman '67
Communications Satellite Corporation
Allan J. Costantin '54
Donald G. Craig '57
Paul M. Craig Jr. '45
Edward J. Curtis Jr. '64
Custer Powell Inc.
Cutler Associates Inc.
DOW Chemical Company
Mrs. Dwight Dwinell '34
Ruth H. and Warren A. Ellsworth Foundation
Neil A. Fitzgerald '38
Leslie Flood '46
A.J. Gifford Charitable Trust
Greater Worcester Community Foundation
Dale G. Freygang '74
Alfred E. Green '45
Hanover Insurance Company
Philip B. Heald
Lawrence B. Horrigan Jr. '56
Industrial Risk Insurers
Allan B. Johnson '46
Joseph H. Johnson Jr. '46
Johnson Controls
Arthur R. Koerber '40
Carlton G. Lutts Jr. '46
Mildred H. McEvoy Foundation
Medical Center of Central Massachusetts
Mobil Foundation Inc.
Fred S. Moulton '44
National Fire Sprinkler Association
Neles-Jamesbury Corporation
NEMA
Werner M. Neupert '54
New England Power Service Company
New England Telephone and Telegraph Company
Robert S. Parks '93 Trust
Polaroid Corporation
The Presmet Corporation
Walter L. Robb
John T. Rushton '39
Sean D.S. Sebastian '83
Shawmut Worcester County Bank
Carl F. Simon Jr. '46
J. Morrison Smith '37
Estate of Edith Gates Snow '26
Robert C. Stempel '55
Sullivan Family
Donald Taylor '49
J. Headen Thompson '36
John G. Underhill '44
David T. Van Covern '53
Charles F. Walters '55
WPI Worcester County Club

$2,500 $4,999

Estate of Leslie Morgan Abbe '22
Paul A. Allaire '60
Allmerica Financial
Diran Apelian
Gerald R. Backlund '55
Paul W. Bayliss '60
C. Edward Bean '44
Bemis Company Inc.
Harvey A. Berger '58
Paul R. Beswick '57
Harold D. Burt '33
George Button II '46
James L. Carr Jr. '74
Mrs. Richard A. Carson '44
Coopers & Lybrand
Frederick J. Costello '59
Michael A. DiPierro '68
Robert E. Duffy '45
Howard J. Dworkin '55
John E. Edfors '55
Leland P. Ekstrom '42
Janet Forkey
John F. Gabranski '75
Michael M. Galbraith '58
General Motors Corporation
Mark S. Gerber '69
David F. Gilbert '54
The Gillette Company
Albert S. Goldberg '48
Robert W. Goodfader '60
Edward L. Griffith Jr. '69
Grinnell Corporation
Michael S. Gutman '58
Daniel J. Harrington Jr. '50
John F. Harvey '77
Mrs. George W. Hazzard
Roger J. Heinen '73
Rolf H. Jensen
Charles C. Johnston '57
Everett M. Johnson '44
Chandler W. Jones '26
Franklin S. June '45
Margaret N. Kalenian
John F. Kelley III '65
Richard D. Kirk '54
Hans H. Koehl '56

Note: *a "**p**" after a name indicates parent(s) of WPI students/alumni.*
* = *deceased*

John Lee '46
Eino O. Leppanen '32
Bruce G. Lovelace '68
Russell R. Lussier '54
James H. Maloney Jr. '46
Marsh & McLennan Companies Inc.
Massachusetts Electric Company
Frank L. Mazzone '46
Richard J. McBride '56
Herman Medwin '41
Merck & Co. Inc.
Microsoft Corporation
Harry L. Mirick Jr. '54
Charles A. Mitchell '46
MITRE Corporation
Alfred A. Molinari Jr. '63
National Fire Protection Association
Northeast Utilities Service Company
David P. Norton '62
Henry W. Nowick '56
Julius A. Palley '46
Public Service Electric & Gas Company
Raymond J. Remillard '49
Roger P. Roberge '45
Rockwell International Corporation
Reynald J. Sansoucy '55
Sara Lee Corporation
Lawrence F. Scinto '51
Kenneth W. Shiatte '53
Society of Fire Protection Engineers
Jon C. and Jean A. Strauss
Warner C. Sturtevant '45
Howard E. Swenson '44
Leonard H. White '41

$1,500 to $2,499

Michael L. Abrams '77
James S. Adams '49
Robert H. Adams '48
Advanced Micro Devices Inc.
Aerospace Corporation
Joseph J. Alekshun Jr. '56
Richard W. Allen '45
Robert C. Appenzeller '46
Arthur Andersen & Company
Christian S. Baehrecke '56
Roy E. Baharian '44
Bruce M. Bailey '51
Richard A. Barlow '57
Jonathan R. Barnett '74
James L. Bartlett Jr. '39
Leon H. Bassett '51
Bechtel Group Inc.
J. William Belanger Jr. '58
C. Gordon Bell '93
Donald F. Berth '57
J. William Bowen '66
Bristol Myers Squibb
Paul W. Brown Jr. '55
Daniel A. Bundza '57
John L. Buzzi '57
Richard S. Carrara '63
Wilder R. Carson '39
Frederick M. Chakour '45
Edwin B. Coghlin Jr. '56
Charles H. Cole '30
Cole Contracting Inc.
Christopher R. Collins '56
Charles F.H. Crathern III '52
David S. Crimmins '58
Gordon F. Crowther '37
Henry S.C. Cummings Jr. '50
Earl M. Curtis '36
C. Marshall Dann '35
Mrs. Phillip R. Delphos '26
Albert M. Demont '31
William P. Densmore '45
Thomas R. d'Errico '41
Robert L. Diamond '56
Walter G. Dick '49
Paul C. Disario Jr. '42
Emerson Electric Company
Cornelius J. Enright Jr. '60
Robert L. Favreau '52
William J. Firla Jr. '60
Ford Motor Company Fund
The Foxboro Company
Timothy A. French '73
Anson C. Fyler '45
Herbert F. Gale '34
Milton W. Garland '20
C. Stewart Gentsch '58
Bennett E. Gordon Jr. '65
Joel P. Greene '69
Peter T. Grosch '69
Richard M. Gross '69
Grumman Corporation
Ralph P. Guertin '62
David H. Hall '68
Leslie B. Harding '41
Warren G. Harding '42
Stephen J. Hebert '66
Thomas S. Heefner '61
John T.E. Hegeman '45
Leonard Hershoff '43
Jay P. Hochstaine '62
Peter H. Horstmann '55
Holbrook L. Horton '29
Hughes Aircraft Company
Clayton E. Hunt Jr. '34
Leonard Israel '44
M Howard Jacobson
Harry T. Jensen '33
Charles F. Jones '48
Steven M. Kay '72
Robert C. Keenan '70
George J. Kennedy '45
William A. Kerr '60
Kinefac Corporation
Douglas W. Klauber '67
Victor E. Kohman '43
Wilmer Kranich
Ernest R. Kretzmer '45
Joseph A. Lagana '67
Walter E. Lankau Jr. '64
Craig B. Laub '77
John H. Lauterbach '66
John B. Lawson '63
John W. Lebourveau '44
Thomas E. Lempges '46
Allen H. Levesque '59
Arthur J. LoVetere '60
Joseph J. Maggi '67
Zareh Martin '40
Martin Marietta Corporation
Robert E. Maynard Jr. '63
Thomas G. McGee '64
John M. McHugh '56
Samuel W. Mencow '37
Ward D. Messimer '39
Charles R. Michel '37
Bruce D. Minsky '77
Robert B. Mirick '39
Monsanto Fund
Morgan Construction Company
Peter B. Myers '46
John M. Nelson
Robert L. Norton
Robert W. O'Brien '38
Mark F. O'Neil '80
Francis J. Oneglia '42
Alex C. Papianou '57
Ronald B. Paris '46
Parker Hannifin Corporation
James Z. Peepas '49
Edward H. Peterson '43
Edward J. Power Jr. '54
John W. Powers '61
Henry B. Pratt '32
Olive Higgins Prouty Foundation
Simon D. Ramo
Edward W. Randall '49
Samuel Ringel '47
Kenneth W. Roberts '68
Rodney Hunt Co.
John H. Rogers Jr. '56
John E. Rogerson '42
Milton E. Ross '40
Stephen E. Rubin '74
Anthony J. Ruscito '70
Philip B. Ryan '65
David M. Schwaber '65
William F. Shields '64
Paul W. Snyder '53
The Stanley Works
Edward Stokel '46
Stone & Webster Inc.
Nam P. Suh
Lawrence R. Sullivan '40
John W. Sutcliffe '38
Claude-Alain Tardy
Marshall B. Taylor '68
W. Gordon Thatcher '40
Francis G. Toce '60
John M. Tracy '52
Irwin T. Vanderhoof '48
Helen G. Vassallo '82
Romeo J. Ventres '48
Davis S. Watson '46
Charles F. Whitcomb '46
Richard T. Whitcomb '43
David H. White '75
Malcolm K. White '46
Philip A. Wild '50
John Wiley & Sons Inc.
John H. Williams '49
Richard B. Wilson '39
Ronald L. Zarrella '71
David A. Zlotek '69
Donald N. Zwiep

$1,000 to $1,499

J. Carleton Adams '23
American Cyanamid Company
Erving Arundale '37
Edwin G. Baldwin '45
Banta Corporation
Gerald J. Bibeault '42
John A. Bjork '44
Mrs. Richard E. Bliven '27
Roland C. Bouchard '66
Edouard S.P. Bouvier '55
BP America
Craig F. Bradley '69
Harrison K. Brown '39
Kevin J. Burke '60
W. Richard Byrnes '54
John W. Chandler '44
Chevron Corporation
Joseph J. Concordia '56
George A. Cowan '41
C. Chapin Cutler Sr. '37
Vladimir T. Dimitroff Jr. '44
Peter C. Dooley Jr. '44
Donald B. Esson '69
Daniel F. Farrar '84
James C. Ferguson '41
Warner S. Fletcher
Fluor Corporation
Victor J. Geraci '84
Arthur and Susan Gerstenfeld
W.R. Grace & Company
Lee P. Hackett '61
Joseph M. Halloran Jr. '40
William E. Hanson '32
Hercules Incorporated
Joachim Herz '54
Neil M. Hodes '70
D. Brainerd Holmes
Hyde Manufacturing Company
International Association for Fire-Safety Science
D. Alden Johnson '54
Timothy C. Johnson '71
Charles A. Kalauskas '69
Andrea J. Fielding Kaneb '84
Arthur T. Katsaros '69
Thomas C. Kee '54
Jean Keller *p*
Atwater Kent Foundation
Morey Kraus
Donald T. Kremer '70
Philip A. Kulin '39
M. Leonard Kuniholm '38
Arthur Lagadinos '46
Peter H. Levine
Carl J. Lindegren III '82
Richard W. Lindquist '54
Francis W. Madigan Jr. '53
Thomas F. Mahar Jr. '55
Carlos A. Maltos Diaz '80
Peter J. Martin '62
John T. McGrath III '36
Millipore Corporation
Paul R. Mullaney '46
Paul E. Nelson '32
Howard I. Nelson '54
Edwin F. Nesman '55
Rowland M. Newcomb '46
New England Power Company
New York Stock Exchange
North American Philips Corporation
William J. Norwood III '81
John F. O'Brien
O'Brien & Gere Engineers
Robert J. O'Malley '39
Robert A. Painter '43
Alfred G. Parker '33
Philip Morris Inc.
Ralph W. Piper Jr. '42
Paul I. Pressel '44
William Price '37
Richard A. Prokop '37
Mr. and Mrs. Gunnar Randholm *p*
John B. Robinson *p*
Robert W. Schramm '46
Richard B. Scott '54
Robert F. Shannon '50
William E. Shanok '64
Irving Skeist '35
Edward H. Smith '46
Southern New England Telephone Company
Society of Fire Protection Engineers
Spag's Supply
Stephen W. Spakowsky '69
Harvey W. Spence *p*
Mr. and Mrs. Roger Sullivan *p*
Edward J. Sydor '50
John W. Sztuka Jr. '70
Donald A. Taft '72
Robert M. Taft '38
Tambrands Inc.
Roger H. Tancrell '56
TRW Inc.
Steven A. Udell '70
United Telephone-Eastern Inc.
Westinghouse Electric Company
Estate of Hester D. Wetherell
Wheelabrator Technologies Inc.
Plummer Wiley '35
Mr. and Mrs. Joseph Wojtowicz *p*

$250 to $999

Crosby L. Adams '57
Donald H. Adams '52
Joseph D. Adams Jr. '76
Aetna Life & Casualty
Arthur M. Aframe '69
Air Products & Chemicals Inc.
Robert E. Akie '73
Akzo America Inc.
Paul R. Alasso '54
James A. Alfieri '59
Patricia A. Allard '83
Robert A. Allen '59
Raymond L. Alvey Jr. '50
Alza Corporation
Amoco Corporation
Arthur W. Anderson '57
G. Albert Anderson '51
Gordon C. Anderson '44
Merico E. Argentati '70
Ashland Oil Inc.
Emanuel S. Athanas '32
ATOCHEM Inc.
Dennis Aves '84
Avon Products Inc.
William E. Bachmann '50
Carl W. Backstrom '30
Frank C. Baginski '45
Everett E. Bagley '52
Brownell M. Bailey '80
Kenneth E. Baker Sr. '52
Norman E. Baker '50
Walter J. Bank '46
George M. Banks '69

C.R. Bard Inc.
Barnett Banks Inc.
Carl P. Baron '77
John H. Barrett Jr. '46
Francis L. Barry '44
Harry S. Barton Jr. '55
Robert W. Batchelder '49
John C. Bayer '45
Edward J. Bayon '31
Karen L. Bean '86
Robert W. Bean '82
Arthur F. Beaubien '81
Paul G. Beaudet '68
Paul H. Beaudry '49
David S. Becker '56
Susan Coombs Becker '84
Todd H. Becker '86
G. Standish Beebe '34
Robert E. Behringer '53
Hugh C. Bell '55
Salvatore J. Bellassai '42
BellSouth Services Inc.
Keith R. Bennett '76
Carl F. Benson '36
Penny J. Bergmann '76
Paul H. Bergstrom '38
Stephen E. Bernacki '70
Eugene R. Bertozzi Jr. '38
Rene R. Bertrand '57
Mark A. Besse '83
Fermo A. Bianchi Jr. '73
J. Alfred Bicknell '33
William R. Bingham '46
Charles N. Bissell '34
Mrs. Harold S. Black '21
John R. Black '53
Louis A. Blanchard '57
Henry S. Blauvelt '39
Laurence E. Blomstrom '56
Earl M. Bloom Jr. '55
Robert E. Boddorff '46
The Boeing Company
Joseph E. Boggio '58
John T. Bok '70
Thomas A. Bombicino '44
Paula Mesite Bordogna '80
Mr. and Mrs. Robert M. Borrelli *p*
Richard J. Bors '73
Boston Edison Company
David P. Bova '63
Henry J. Bove '47
John R. Boyd '69
Michael J. Boyden '74
Russell P. Bradlaw '49
Mr. and Mrs. Charles J. Brady Jr. *p*
Ronald S. Brand '40
Melvin H. Bredahl '46
Alan S. Breitman '70
Fred J. Brennan '49
Fred T. Brierly Jr. '42
Alan K. Briggs '76
George E. Brooks '36
Frederick G. Broshjeit '59
John J. Brosnihan '67
Gedney B. Brown '55
Paul J. Brown Jr. '73
James R. Buchanan '60
Gary S. Bujaucius '77
Steven M. Burgarella '84
Henry K. Burger '53
Richard F. Burke Jr. '38
Donald M. Burness '39
Thomas I. Burns '74
Newton H. Burr '44
Carrol E. Burtner '47
Clifford W. Burwick '56
Scott J. Bury '88
Richard C. Butterworth '55
Robert H. Cahill '65
Jean Salek Camp '84
Bernard M. Campbell Jr. '58
Edwin C. Campbell '43
Campbell Soup Company
Mr. and Mrs. Armand Capistran *p*
Capital Cities/ABC Inc.
Elso R. Caponi '45
Dana B. Carleton '32
Carl H. Carlson '29
Allen S. Carnicke '75
John W. Carpenter Jr. '46
Patricia A. Martone Carrolo '84
Kenneth L. Case '69
William P. Casey Jr. '76
Donald E. Casperson '69
Victor B. Castellani '62
Paul M. Castle '66
Lee W. Catineau '54
Donald A. Cauley '77
Robert L. Chang '55
Richard M. Chapman '58
Walter J. Charow '49
Raymond F. Cherenzia '73
Alexander S. Chodakowski '41
Paul A. Christian '73
Chrysler Corporation
Church & Dwight Company Inc.
CIBA-GEIGY Corporation
Todd R. Cimino '84
Wayne J. Civinskas '77
George A. Clark '74
J. David Clayton '44
Clorox Company Foundation
Edward H. Coburn Jr. '48
Richard A. Coffey Jr. '51
Morrel H. Cohen '47
Matthew V. Colagiuri '88
Raymond W. Coleman '72
Commonwealth Electric Company
Commonwealth Gas Company
George E. Comstock '46
Consolidated Edison of New York
George H. Conley Jr. '46
John F. Conlon Jr. '55
The Connecticut Light & Power Company
Connecticut Mutual Life Insurance Company
Robert F.I. Conte '57
J. Desmond Cook '86
John R. Corf '46
Nicholas A. Cotsidas '62
Richard H. Court Jr. '67
John B. Coyle '35
Roger M. Cromack '48
Philip B. Crommelin Jr. '52
Marshall W. Cross '64
Kevin J. Crossen '73
Catherine M. Culnane '84
William D. Cunningham '77
Robert Cushman
Mr. and Mrs. Paul C. Cutroni *p*
Merritt E. Cutting '34
Walter G. Dahlstrom '36
Bernard R. Danti '56
George G. Davenport III '69
Warren H. Davenport '34
Daniel L. David '72
Harold C. Davis Jr. '44
Michael A. Davis '62
Paul W. and Sharon C. Davis
Dr. and Mrs. Ross Davis *p*
Davis Corporation of Worcester
Debra R. Weinstein Dean '83
Phillip S. Dean '35
Henry N. Deane '31
Domenic W. DeAngelo '79
James J. DeCarlo Esq. '80
John L. Dehnert '59
Gene E. DeJackome '74
Delta Air Lines Inc.
Howard J. Dember '48
David P. Demers '74
Mr. and Mrs. William A. Demicco *p*
Allen R. Deschere '38
Susan A. Butler DesMarais '86
Ralph A. Desrosiers '88
Dexter Corporation
Thomas M. Di Francesco '73
Richard J. DiBuono '62
Arthur M. Dickey '65
Richard J. Dickey '85
Gregory S. Dickson '71
Robert G. Dietrich
Mario P. DiGiovanni '75
Stephen P. Diguette '72
Anne M. McPartland Dodd '75
Glenn W. Dodwell '77
Dan D. Doherty Jr. '81
Alfred R. Doig Jr.
Mr. and Mrs. Herbert J. Doller *p*
Michael W. Donahue '90
William J. Dowd '64
David A. Drab '85
Randall P. Drabczuk '84
John E. Driscoll '28
Alfred L. Dunklee '61
Linda S. Dunn '84
Joseph B. Dzialo '76
Wayne E. Eastman '70
Robert M. Edgerly '45
Charles J. Egan '34
Edward W. Eidt Jr. '57
Eli Lilly & Company
Richard M. Elliott '38
Franklin P. Emerson '49
Ensign-Bickford Foundation Inc.
Richard E. Epstein '63
Stephen A. Erikson '69
Paul E. Evans '48
Factory Mutual System
David R. Fairbanks '52
Alan S. Feitelberg '84
Peter R. Fenner '64
Martin P. Ferguson '84
Richard J. Ferguson '57
Oscar A. Fick Jr. '38
Joseph L. Fischer '46
Mr. and Mrs. Thomas P. Fischer *p*
Niel I. Fishman '48
Robert W. Fitzgerald '53
John J. Fitzgibbons Jr. '75
Stephen L. Fitzhugh '75
Patricia A. Graham Flaherty '75
Robert J. Flaherty '85
Robert W. Flanagan Jr. '74
Florida Power & Light Company
James D. Fogarty '61
Warren F. Follett '69
Alan S. Foss '52
Thomas R. Fournier '69
George F. Foxhall '61
Charles S. Frary Jr. '34
Roger F. French '44
Linda S. Fritz '74
Richard W. Frost '62
Richard C. Furman '69
John J. Gabarro '61
Michael Gaffin '55
Andre F. Gagnon '80
Cynthia L. Gagnon '82
Theodore E. Gazda '46
John H. Geffken '63
General Dynamics Corporation
William F. Gess Jr. '58
F. Clark Gesswein '64
Frederick C. Gilbert '48
David A. Gillespie '82
Andrew J. Giokas '70
Donald J. Girard '46
Donald P. Givens '66
Joseph Glasser '35
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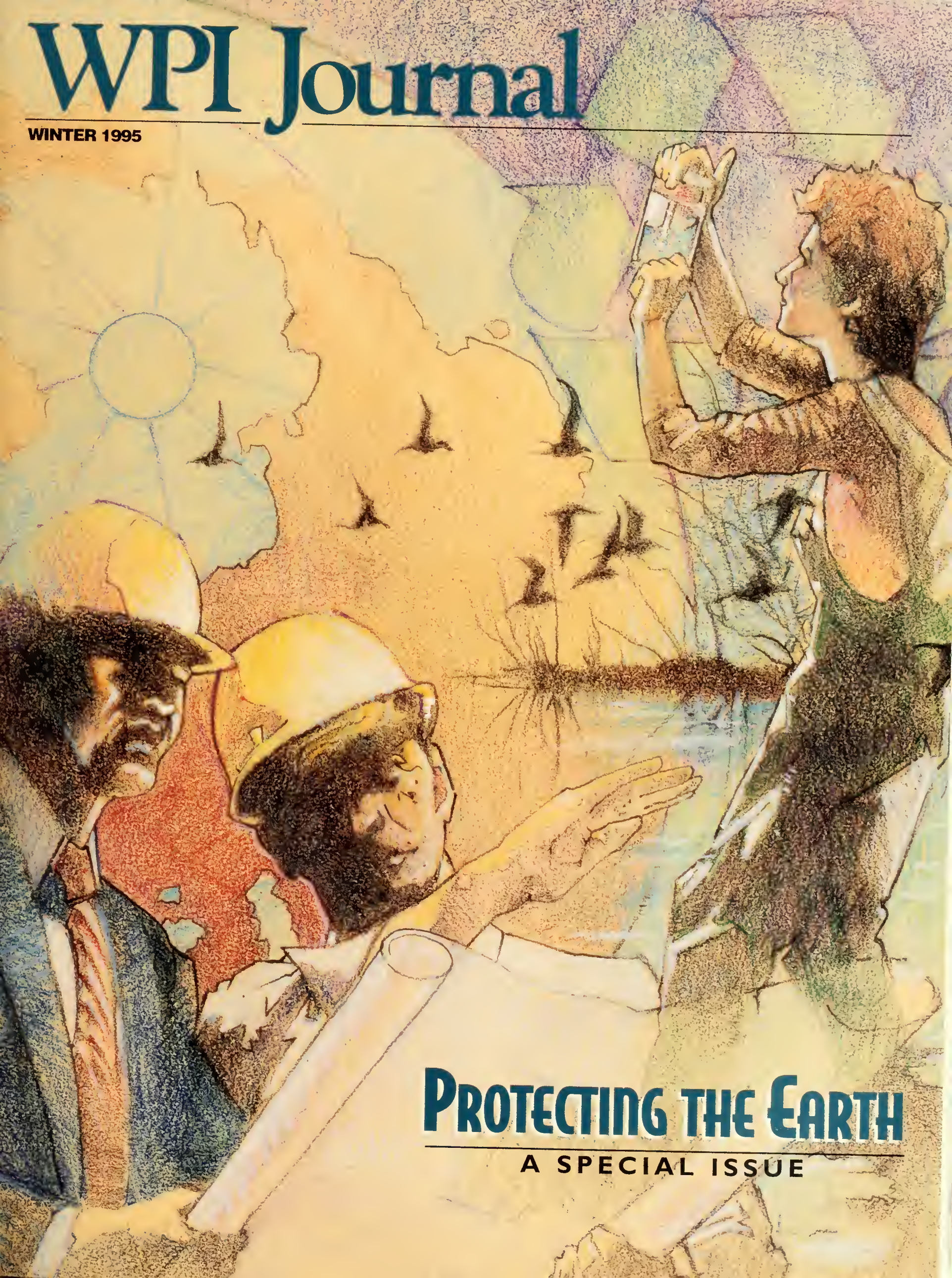

PROTECTING THE EARTH

A SPECIAL ISSUE

WPI Journal

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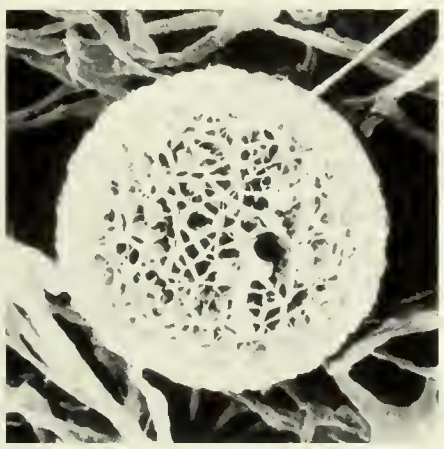
FEATURE

18 **Stewards for a Small Planet**

David Brooks, Alison Chisolm, Diane Benison, Michael Dorsey, Joan Killough-Miller and Ruth Trask

It's been more than three decades since Rachel Carson's *Silent Spring* awakened the world's environmental consciousness. In that time, hundreds of alumni have used their WPI education as a stepping-stone to rewarding careers in environmental management and protection. Here are some of their stories.



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4 **Letters**
A disappointing celebration; Marietta Fletcher also a Sinclair; thanks for the Internet story; promote, but don't mandate, the F.E.; Fine's article "timely and necessary."

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32 **Final Word** *Joan Killough-Miller*
The search for Everett Leach.

Cover: Illustration by Robert G. Cuoco. Story on page 18. Opposite: By good fortune, a great deal of this winter's sparse snowfall arrived in time for the 1995 Winter Carnival, held recently. The WPI community enjoyed such wintry activities as snow sculpting and frozen turkey bowling (seen here). Photo by Jason Philbrook '97.

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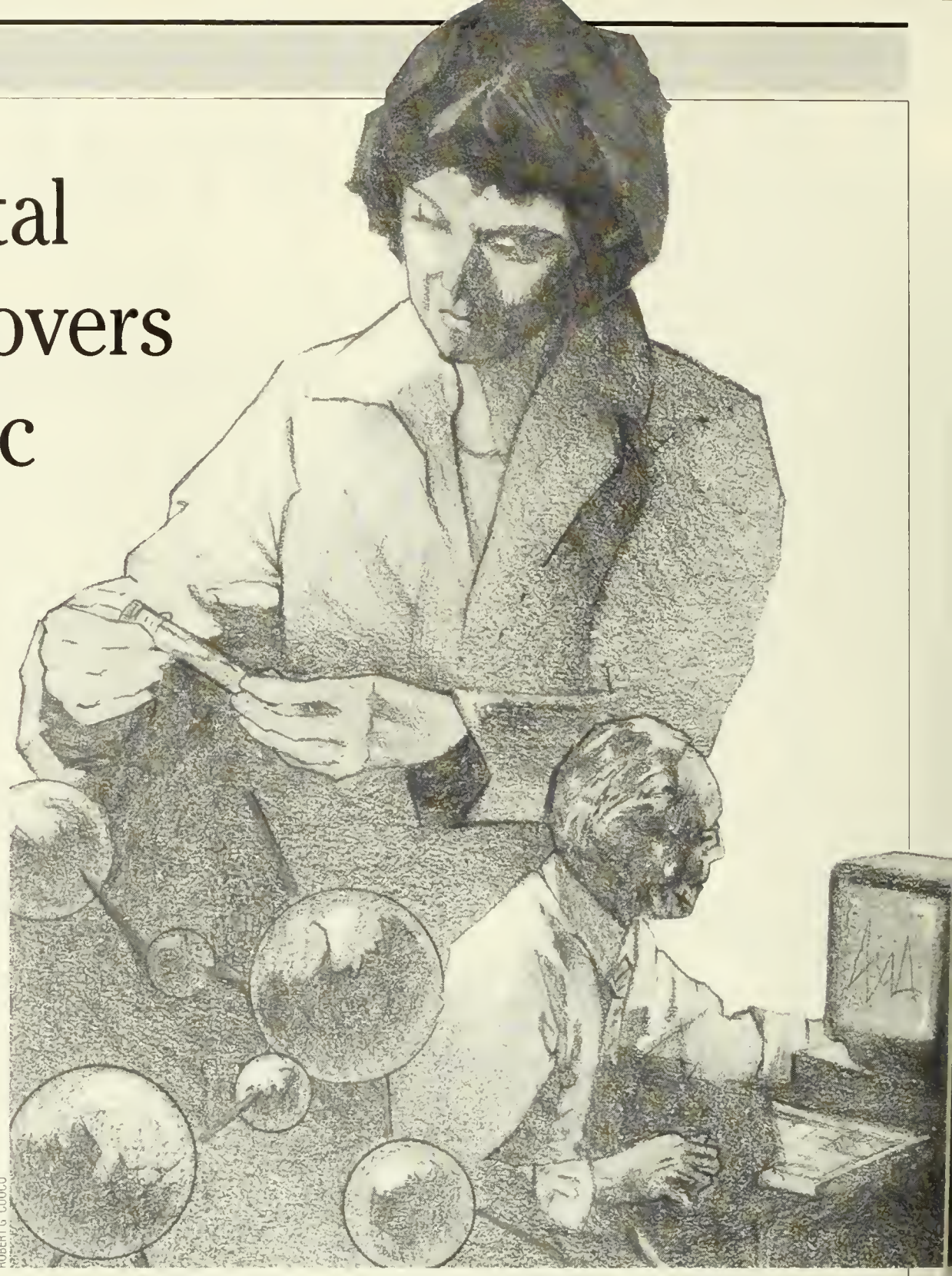
Environmental Education Covers the Academic Spectrum at WPI



ROBERT G. CUOCO

By Michael Dorsey

In this special issue of the *WPI Journal* we look at the field of environmental science and engineering. Starting on page 9, we report on four projects with environmental themes completed by WPI undergraduates at the far corners of the globe. Beginning on page 12, you'll find profiles of five current research projects that revolve around ecology, environmental engineering and environmental psychology. Finally, starting on page 18, we present eight stories of WPI graduates who have built interesting careers in the environmental arena.

There is, of course, another side to the environmental field at WPI—environmental education. Since the dawn of the WPI Plan in the early 1970s, students have been able to take courses, pursue undergraduate majors, and complete projects in environmental studies. In the early days of the Plan, most of the courses and majors were pursued through the Interdisciplinary Studies Division (now the Interdisciplinary and Global Studies Division). Since then, the environment has become the focus for programs centered in eight academic departments and programs (including Interdisciplinary and Global Studies), and opportunities for students to concentrate their course and project work in an environmental discipline have grown dramatically.

WPI's 1995-96 undergraduate catalog devotes two pages to describing the range of environmental offerings available at the undergraduate level. Emphasis areas in environmental engineering exist in the Chemical Engineering Department, the Manufacturing Engineering Program, the Mechanical Engineering Department, and the recently renamed Civil and Environmental Engineering Department.

The civil and environmental program focuses on water quality control systems related to water supply and waste treatment. The chemical engineering program introduces students to areas like pollution prevention, environmentally friendly packaging, and the abatement of air, water and soil pollution. In manufacturing engineering and mechanical engineering, the emphasis is on designing products to minimize environmental impact and on environmentally conscious manufacturing.

Other emphasis areas have been created in the departments of Biology and Biotechnology, Humanities and Arts, and Social Science and Policy Studies. The focus areas in biology and biotechnology include ecology and environmental biology. In humanities and arts, students may pursue a degree in literature, history, or philosophy and religion with an environmental orientation, preparing for careers in such fields as law, business, government service, environmental activism and journalism.

In social science and policy studies, students can focus on environmental issues as part of any of the department's three existing degree programs: economics, economics and technology, and society, technology and policy. Currently in development is a new degree program called environmental policy and development.

Sustainable development will be a theme that permeates the new major program, says Michael J. Radzicki, associate professor of social science and policy studies and one of the creators of the new major. "The philosophy of sustainable development is: don't use renewable resources faster than they can be substituted for; don't create any more pollution than can be assimilated by the environment; and don't encourage more growth than the environment can support. In essence, the idea is to tie your standard of living to the carrying capacity of the environment."

Students will explore the requirements for and difficulties of sustainable development in a number of ways. For example, they will use a computer simulation being developed by an Interactive Qualifying Project team. In the game, players attempt to run a nation on a sustainable basis, deciding how much of the country's labor resources to allocate to things like manufacturing and renewable resource stewardship. Through projects like this one, students at WPI can explore real-world environmental problems and issues and get valuable insight into the kinds of social, technological and political interactions they are likely to encounter in their careers.

Each year, dozens of students complete IQPs, Sufficiencies and Major Qualifying Projects with environmental themes. Most are students who do not intend to pursue an environmental degree program or emphasis, but who have a strong interest in understanding the potential ramifications of the environment in their careers and lives.

The topics for these projects are far-ranging. Of the 12 broad thematic divisions in which IQPs are categorized, four touch directly on environmental issues: Environment and Technology; Energy and Resources; Regional Studies and Planning; and Economic Growth, Stability and Planning. Project teams working in these divisions in recent years have looked at the effectiveness of automobile recycling, studied atmospheric pollution in Athens, and prepared environmental curricular materials for local public schools.

Through WPI's corporate project centers, MQP teams have tackled many environmental problems of concern to managers at companies like Norton, Raytheon, Polaroid, Wyman-Gordon and Monsanto. At Norton, students have helped the company experiment with converting its fleet of vehicles to run on natural gas and helped find ways to reclaim and reuse abrasives used to make grinding wheels. At Raytheon, students have helped find alternatives to the ozone-depleting chemicals used in metal cleaning and finishing processes.

"These projects are very popular," notes Richard D. Sisson Jr., professor and head of the Manufacturing Engineering Program.

"These projects are very popular. That's a reflection of the interest students have in the environment. They want to do some good for society and they feel this is something to which an engineer can make an important contribution."

— Richard D. Sisson Jr.

"That's a reflection of the interest students have in the environment. They want to do some good for society and they feel this is something to which an engineer can make an important contribution."

Increasingly, students are traveling overseas to complete such projects. The stories starting on page 9 provide just a few examples. Some of WPI's international project centers, including the Ecuador Project Center in Guayaquil and the Venice Project Center, were created, in part, to address environmental issues, but opportunities to pursue projects with environmental themes exist around the world.

A recent grant from the Fund for the Improvement of Post-Secondary Education is making it easier for students to do environmentally related projects overseas—and for students from overseas to complete environmental studies in this country, according to Lance Schachterle, assistant provost for academic initiatives and principal investigator on the grant. The grant supported the creation of the United States/European Community Environmental Projects Coalition, which is being run by WPI in cooperation with Howard University, the Technical University in Darmstadt, Germany, the Eindhoven University of Technology in Holland, and the University of Limerick in Ireland.

WPI students who travel to Europe are likely to learn about some of the most comprehensive environmental laws in the world, Sisson says. "A few European nations, including Germany, essentially say that a company owns its products for the entire life of those products. If you buy a computer, the company has to take it back when you are done with it and recycle or reuse it. This is something our engineers need to become familiar with."

Funding from the AT&T Foundation is supporting an innovative effort to teach students about the importance of multidisciplinary teams in manufacturing enterprises through the use of case studies (*WPI Journal,* Spring 1994). One of the studies, developed by Sharon Johnson, associate professor of management, James O'Shaughnessy, professor of civil engineering, and Sisson, looked at a waste elimination program developed by Hyde Manufacturing Co. in Southbridge, Mass., a maker of household tools and knives.

Not all of the environmentally related course and project work takes place at the undergraduate level, of course. WPI currently offers master's and Ph.D. programs in environmental engineering through the Civil and Environmental Engineering Department (in fact, about half of the department's graduate students are pursuing environmental degrees). Students also frequently complete master's theses and doctoral dissertations on environmental topics in many other departments. In addition, courses that delve into environmental issues are offered in a number of disciplines. In Manufacturing Engineering, for example, a new course developed and taught by Sisson and O'Shaughnessy introduces students to environmental issues in manufacturing.

"This course is quite timely," O'Shaughnessy says, "because we are seeing great changes in manufacturing and environmental engineering. The chemical industry has said

that in the 1990s, the cost of environmental compliance will exceed the cost of raw materials in manufacturing. But even more, industry is coming to see that minimizing waste and pollution makes good business sense. When you recover a waste and reuse it, you spend less on raw materials and on equipment to treat waste."

O'Shaughnessy, who has served as chairman of the American Society of Civil Engineers Task Force on Pollution Prevention, obtained funding from the Massachusetts Toxic Use Reduction Institute at the University of Massachusetts to teach courses on toxic use reduction through WPI's Continuing Education Office. Also participating in the courses, which help companies comply with the Massachusetts Toxic Use Reduction Act, were Sharon Johnson and Raymond Lizotte, an engineer at Texas Instruments.

At the undergraduate level, O'Shaughnessy is team leader for environmental course and project materials being developed by the Realization Consortium, which is pioneering a new approach to engineering education with a major grant from the federal Technology Reinvestment Program (*WPI Journal,* Spring 1994). Led by WPI, the consortium also includes Cornell, MIT, North Carolina A&T and Tuskegee.

"I'll be focusing on pollution prevention and waste minimization in the materials I'll be developing," O'Shaughnessy says. "The idea is to put together course modules that can be used at any of the participating schools—in fact, at any school that teaches engineering and design. We eventually hope to put these materials on the World Wide Web (see page 6) to make them widely available."

With topics like waste minimization, pollution prevention and design for the environment to ignite students' interest, O'Shaughnessy says the job of getting students excited about environmental issues is becoming easier. It's a change he says he's seen in his own career as an environmental educator and consultant.

"Until recently, I was always reactive, working at the end of the pipe to clean up the waste generated by manufacturers," he says. "When you talked to industry about waste treatment, they became defensive. Now we can be proactive. We talk about reducing waste and saving money, and industry gets excited. That gets me excited too. Now our job is to pass that excitement on to our students."

A Disappointing Celebration

To the Editor:

Upon receiving the Spring 1994 *WPI Journal,* I looked forward to reading "Memories of a Quarter Century: Celebrating 25 Years of Women at WPI." When my husband, Paul '68, attended WPI, there were no women students. As the parent of two daughters, Jaime (Yale '98) and Erin (a high school junior), it was interesting to look at the history of women at WPI.

However, I was upset to note that in your "celebration" of 25 years of women's accomplishments, you were unable to highlight the accomplishments of any women in any of the accompanying articles. I counted 12 separate articles about men and 31 pictures of successful men (along with a photo of one lone woman). Were no women graduates in 25 years worthy of mention? Have no women been successful enough to highlight, especially in this celebration issue? What kind of message are we sending our daughters, female students and female alumni—that their accomplishments just don't rate? What a disappointment!

Susan Arruda
Wilmington, Del.

Marietta Fletcher Also a Sinclair

To the Editor:

What a wonderful surprise it was to see the picture of my great-grandmother, Marietta Fletcher, at the top of page 12 in the Spring 1994 *WPI Journal.* My mother, still alive in her 90s, remembers her grandmother with loving affection.

Marietta S. Fletcher was indeed one of the first female members of the WPI faculty. Her education included an extended visit in the home of a German family, where she gained a deep sense of familiarity with Germany and its people. She taught English, French and German at WPI (then the Worcester Free Institute). In 1870, only a few years after the founding of the Institute, she married Professor John E. Sinclair, who taught mathematics at WPI. While Marietta's tenure as a teacher lasted only a few years, her husband remained with WPI for nearly four decades as head of the Mathematics Department.

It is unfortunate that your article did not mention Marietta Fletcher's married name of Sinclair. I believe she married during the period when she was teaching. The arrival of her first child, my grandmother Luise Sinclair, caused her to leave her teaching post.

Incidentally, Marietta's (and John Sinclair's) descendants have maintained a close relationship with WPI. They include myself, Louis C. Smith (WPI Class of 1872), David S. Cummings '72 and Stephen J. Cummings '76. I serve on the President's Advisory Council. The present John E. Sinclair Professorship at WPI was funded by Professor Sinclair's life insurance, the beneficiary of which was Marietta, until her

death. Also, the manufacturing company started by Professor Sinclair, now called Lowell Corp., has created the John E. Sinclair Scholarship Fund at WPI.

Thank you for the article "O Pioneers," which put the highlight on my great-grandmother. May her memory be preserved for years to come.

HENRY S. "PETE" CUMMINGS '50
HOLDEN, MASS.

Thanks for the Internet Story

TO THE EDITOR:
Thank you for your excellent article on the Internet in the Summer 1994 *WPI Journal*. I am a member of the "slide-rule generation" who is trying to educate myself in the ways of computers. Any help I can get is very welcome.

While I have always enjoyed reading WPI publications, this article is the most personally useful one I have read in the *Journal* during the past 39 years. Please include more of this type of article in the future.

PHILIP C. JONES '55
CHARLESTOWN, R.I.

Promote, But Don't Mandate, the F.E.

TO THE EDITOR:
I read with great interest Morton Fine's article in the Summer 1994 *WPI Journal* suggesting that the ABET accreditation process for engineering curriculums include a mandate that all seniors sit for the Fundamentals of Engineering (F.E.) examination ("Academia is Shortchanging New Engineers"). While I understand the arguments advanced by the author, I disagree with his conclusions.

The thrust of the article is that practicing engineers should see that new graduates are required to take the first step toward registration, whether they wish to or not. The article stresses the difficulties imposed by waiting beyond graduation to start the process and appears to define registration as a prerequisite to a successful career.

Having waited until 12 years after graduation to take the F.E. exam, I will admit that it is made more difficult by the passage of time. In my case, the delay was not due to trepidation about taking the exam. Rather, it reflected the reality that, as an engineer and manager in a large manufacturing company, there was no benefit at all to my being registered. Only after I decided to redirect my career toward consulting did any benefits arise. While the delay did not enhance my taking the exam, it did not prevent me from preparing for and passing it, nor would it do so to others.

In fact, a greater impediment to registration for individuals in a manufacturing environment is obtaining the letters of recommendation from P.E.s familiar with the individual's work, which must be submitted as part of the application process. I know several individuals who have avoided applying because of this requirement, and not because of examination issues.

Admittedly, it would have been more convenient had I taken the exam while in school. However, the end of a student's senior year is not necessarily the best time to include an additional mandated requirement, especially one as stress-laden and requiring as much preparation as the F.E. exam. Coupled with the costs of taking the exam (fees for registering with the state for the exam, fees to the testing company for taking the exam, and more fees for completing registering with the state after passing the exam), it can be argued that the immediate benefits to the student do not outweigh the cost.

"The end of a student's senior year is not necessarily the best time to include an additional mandated requirement."

"More effort should be devoted to this subject in order to inform WPI students about the importance of engineering registration."

While there are some professional drawbacks to not being registered, the list is not as extensive as implied by Mr. Fine. I'm not sure which professional societies restrict full membership to P.E.s (certainly not AIChE), but the lack of registration has little or no effect on most careers. The great majority of registered engineers practice in consulting roles. Certainly, a P.E. is necessary if one wishes to open a one-engineer shop, but for most engineers practicing as employees there is no pressing need.

Regarding the ability of a physician to use the title M.D. without having to be licensed to practice, an engineer is just as free to use the titles B.S., M.S. and Ph.D. after his or her name. Many Ph.D. recipients freely use the honorific "Doctor" prior to their names. Achieving registration has no bearing on the use of these titles, nor on the prestige and respect that is or is not granted to them. More commonly, nonengineers either question the meaning of the initials P.E. or have no idea of their significance. Even among engineers, the title is sometimes seen as an achievement worthy of merit, but not one of consequence.

Perhaps before those of us in practice impose another requirement upon graduating seniors, we may want to become better educated about professional registration ourselves. Once we have defined the benefits of registration and reached agreement as to the value thereof, we can consider requiring seniors to join us. Until that time, a more aggressive informational campaign, using such resources as student society chapters, may be our best means to promote the initiation of the registration process.

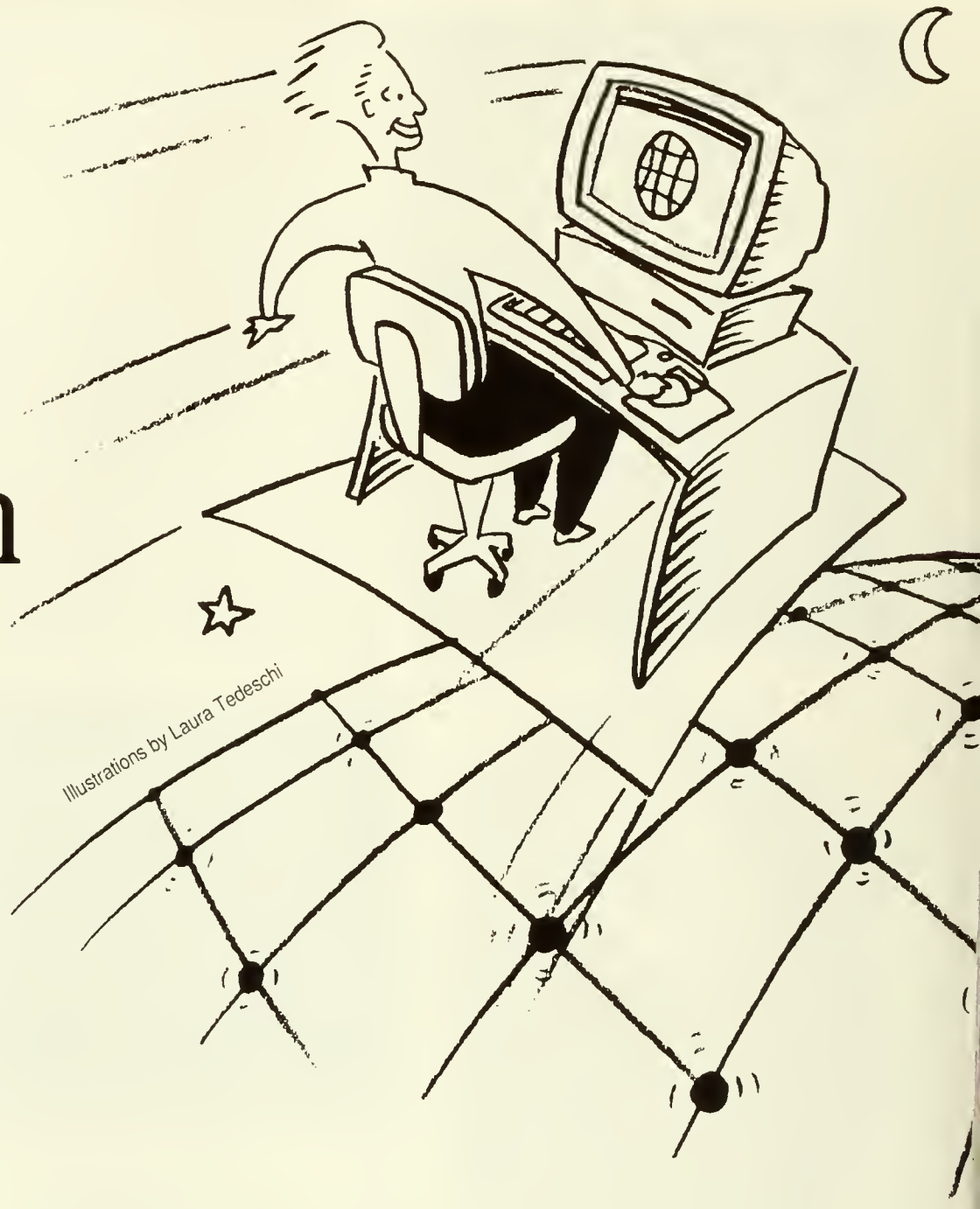
GEORGE A. DAINIS '79 P.E.
MANSFIELD, MASS.

Fine's Article "Timely and Necessary"

TO THE EDITOR:
I read Morton Fine's article "Academia is Shortchanging New Engineers" (Summer 1994) with great interest. It was timely and necessary. It also reflects my sentiment on the subject. I wrote similar articles myself more than 20 years ago for professional publications. I believe more effort should be devoted to this subject in order to inform WPI students about the importance of engineering registration.

VICTOR (VUNG) K. CHUN '51 P.E.
LOS ANGELES, CALIF.

Another Spin on the Information Highway



Illustrations by Laura Tedeschi

Editor's Note: *In the Summer 1994 issue, we brought* WPI Journal *readers up to speed on the vast and constantly growing Internet ("Net Assets"). The response to that story has been quite positive, and we've received a number of requests to provide readers with similar information on a regular basis. (It should be noted that many of those requests arrived by e-mail, at least a few sent by readers who were enticed into taking their first steps into cyberspace after reading the* Journal*).*

In that spirit, we introduce this new department. We'll use this corner of the Journal *to talk about new developments in science and technology and to define and demystify some of the buzzwords you may find yourself reading about in newspapers and magazines (and, perhaps, on-line). In this first installment we'll continue our dialogue on the Internet and tell you how alumni may soon be able to venture into cyberspace courtesy of the WPI Alumni Association.*

The World Wide Web: Future Shock Meets the Internet

In an article in *Harper's Magazine* in 1965, author Alvin Toffler defined future shock as "the dizzying disorientation brought on by the premature arrival of the future." Over the past three decades, the future has been arriving with greater and greater speed. In 1995, it seems that what's hot today can turn cold in the blink of an eye and today's emerging technology can become tomorrow's household tool.

The World Wide Web is a good case in point. Last summer, when we mentioned the Web in the *Journal,* this Internet service was still coming into its own. Since then, the Web has exploded, with thousands of new sites having come on-line and many more being added every day.

Having broken through the informal ban on the use of the Internet for blatant advertising, the Web is becoming an almost mandatory storefront for companies and corporations of all sizes. And with its ease of use, potential for dazzling and creative graphics, and its ability to speed text, pictures, sound and video to computers all over the world, the World Wide Web is quickly eclipsing Gopher, yesterday's hot Internet tool.

A good indicator of the Web's growing popularity is its increasing presence in the media. Stories on the Web abound in newspapers and magazines. The national newsweeklies *Time* and *Newsweek* now have columns on electronic resources that regularly feature Web sites, as do frequent articles and columns in major newspapers.

The Web was conceived in 1989 by scientists at the CERN in Geneva and developed over the course of the next few years. It employs a concept called hypermedia,

which means that the documents one retrieves through the Web may contain links that, when clicked with a mouse, will transport a user to other information, often located on another computer in some other corner of the world.

The first Web browsers (software needed to take advantage of the Web's hypermedia format) were text-based. In 1993 the first multimedia browsers appeared. The most popular is Mosaic, created by the National Center for Supercomputer Applications. By the end of 1993 the first versions of Mosaic written for personal computers were released, setting the stage for the popularization of the Web.

To use the Web, you'll first need access to the Internet. See the Summer 1994 *Journal* for some tips for getting connected or pick up one of the books mentioned in that issue or any of a slew of other Internet books now at bookstores. For personal use, you'll need a recent generation Macintosh or an IBM-compatible computer with enough power and memory to run Microsoft Windows 3.1.

You'll also need a browser. You can retrieve Mosaic by ftp from ftp.ncsa.uiuc.edu (the directories are /PC/Mosaic and /Mac/Mosaic). Netscape is a commercial product that can be obtained free by ftp for evaluation purposes (be sure to read the license that comes with the package for details on long-term usage restrictions.) It's at ftp.mcom.com in the /netscape/mac and /netscape/windows directories.

To use these programs you will likely need other software (MacTCP for the Mac and a Winsock.dll and a windows 32-bit upgrade for Windows). The installation instructions that come with the software will explain these requirements and may point you to shareware versions of the packages.

Things will get easier for Windows users this year when Windows 95 is finally released with its built-in Internet software. IBM's new Warp version of OS/2 already provides this function. Also, commercial Internet software is available that makes using the Web much easier (one popular package is called Internet-in-a-Box). Internet service providers often equip users with Web software, and if you belong to an on-line service like CompuServe or America On-Line, you should get Web access later this year. (Users of Prodigy already have it.)

OK, you've got your browser installed and working. So where do you go? Here are a few interesting places I've found. The first three are actually useful lists that will link you to many, many other sites. Try these to start with. In no time, you'll find yourself ranging far and wide around the Web as you follow the links. To travel to the following sites, you'll need to learn how to type in a URL (Universal Resource Locator—a fancy name for an Internet address) with your browser. In the examples below, the URLs are in **bold type.**

Yahoo: A Guide to the WWW: **http://akebono.stanford.edu/users/www_server/**

The Whole Internet Catalog: **http://www.digital.com/gnn/wic/**

ElNet Galaxy: **http://galaxy.einet.net/**

Library of Congress: **http://lcweb.loc.gov/homepage/** A wealth of information; the Global Electronic Library has links to federal government Web servers, including the White House, as well as many World Wide Web guides; Thomas has the full text of bills before the House of Representatives and a guide to how laws are made.

National Public Radio: **http://www.npr.org/** Story lineups, recipes and other information from a host of NPR news programs.

The Virtual Tourist: **http://wings.buffalo.edu/world/** You start with a map of the world, select a region and ultimately work your way down to clickable maps of World Wide Web sites in specific states or nations.

Zarf Guide to Interactive Games: **http://www.cs.cmu.edu:8001/afs/cs.cmu.edu/user/zarf/www/games.html** These are games and other unusual diversions accessible through the Web, including chess, a tarot card reader and the Magic 8-Ball. Also check out **http://www.yahoo.com/Computers/Internet/Interesting_Devices_Connected_to_the_Net/** to see some of the strange things people have hooked up to the Net, including cameras continually trained on offices, doors and aquariums.

—Michael Dorsey

Building a New Home on the Web

One of the sites you can visit on your Web excursions is WPI (**http://www.wpi.edu/**). Recognizing how easy the Web makes it to access and retrieve information, WPI late last year formed a committee, led by Helen Shuster, director of the Gordon Library, to design a new Web server that would offer visitors a more comprehensive, useful and easy-to-navigate bundle of information about the university.

The result of the committee's work recently went on-line. Visitors arrive first at the WPI home page, a concise, attractive and simply organized departure point. A **Visitors Center** provides newcomers with information about WPI and even a virtual tour of the campus. An on-line **Admissions Office** (still in development) will cater to the interests and needs of potential undergraduate and graduate students and will even allow students to apply through the Internet.

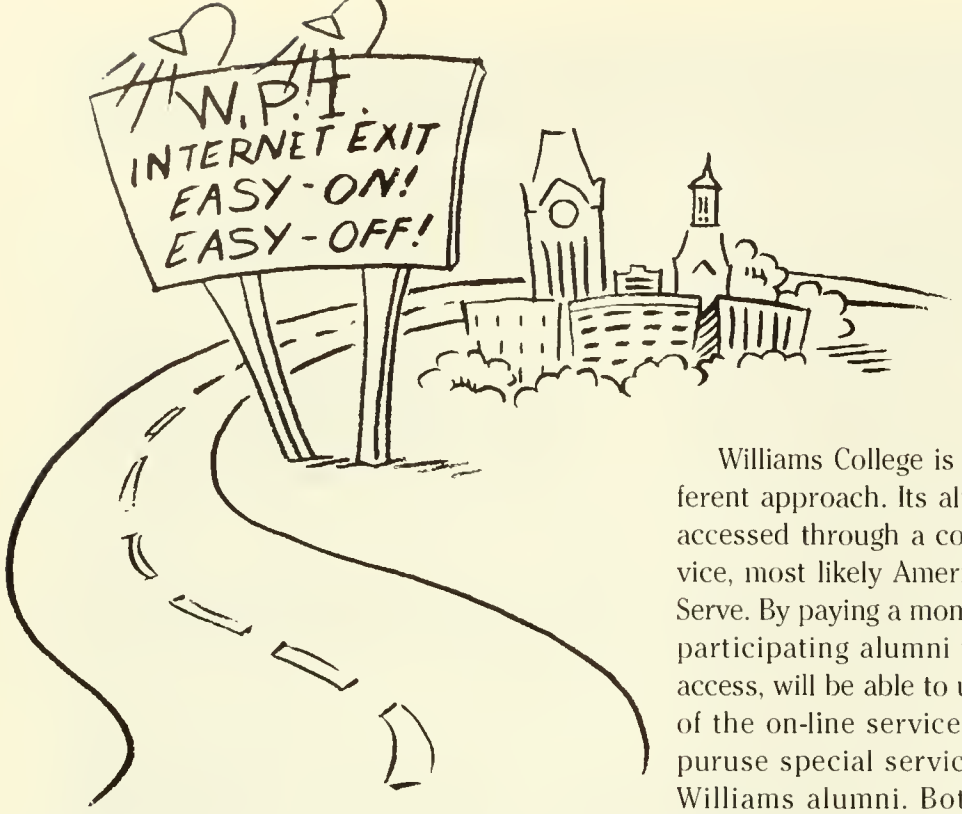
Other buttons on the main menu lead to, among other things, home pages for academic and administrative departments and campus organizations (a selction of the Gordon Library's on-line services can be reached through the Web), WPI publications (including the undergraduate and graduate catalogs), news releases and calendars, periodicals (including the *Journal*), information about WPI educational programs (including, eventually, courses offered through the Web), a campus phone book, and personal home pages maintained by members of the WPI community. There is even a guest book to "sign" and a place where visitors can leave suggestions or request more information about what they find on our Web site.

The WPI Web pages will always be under construction, as Web page builders are fond of saying, with new information being added all the time. We hope Net browsers (people, not software, that is) will find many reasons to stop back often.

—MD

New WPI Network Aims to Get Alumni On the Internet

The wealth of information now being made available on the WPI World Wide Web server should be of special interest to alumni who want to stay in touch with goings-on at their alma mater. But to get at this treasure trove, one needs access to the Internet, something



that can cost at least $20 per month—a sum that may seem a bit steep for many.

All that may soon change. Currently an ad-hoc committee of the Alumni Council, spurred by a suggestion from WPI's College Computer Center (CCC), is exploring ways to give alumni who have their own computers and modems an inexpensive and easy route not only to WPI's on-line offerings, but to the Internet at large. The committee is chaired by Harlan Williams '50 and is being assisted by Margaret Riley of the Gordon Library and the staff of the CCC.

The committee has taken a look at other universities that offer this service to their alumni, including RPI. Rensselaer Alumni Network News (RANN) employs a dedicated computer on campus that alumni can reach through their modems. Users are charged a $40 monthly service fee. For that they get access to the Internet and to alumni and campus newsgroups and information.

One drawback to the RPI arrangement is the fact that alumni outside of the local calling area must pay long-distance charges on top of the monthly fee. In addition, if WPI were to implement such a system, issues such as the cost of the necessary equipment, the responsibility for maintaining it, controlling access to the network, and the potential for the network to strain computers also used by faculty, students and staff would have to be addressed.

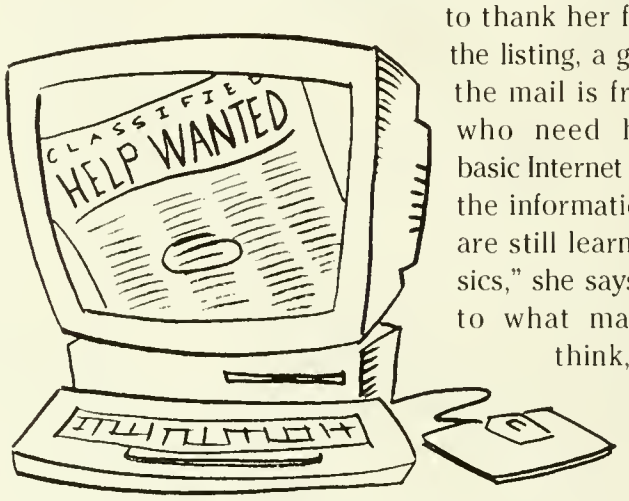
The cost of dialing into the network could be reduced by linking alumni to WPI's computers through a data communications service such as Infopath, a service of NYNEX. Through Infopath, callers in Eastern Massachusetts would dial a local NYNEX modem bank, rather than calling long-distance to Worcester. Their call would be routed to WPI through NYNEX data communications paths and callers would be billed by NYNEX based on the quantity of data transmitted over the telephone lines.

Williams College is trying an entirely different approach. Its alumni network will be accessed through a commercial on-line service, most likely America Online or CompuServe. By paying a monthly fee as low as $10, participating alumni will get full Internet access, will be able to use all of the offerings of the on-line service, and will be able to puruse special services available only to Williams alumni. Both CompuServe and America Online services can be reached via a local phone call from much of the country.

Harlan Williams says the committee would appreciate feedback from alumni concerning how they might use the proposed network and what information they would like to have made available to them. Questions, comments and suggestions can be addressed to Williams through the Alumni Office (100 Institute Road, Worcester, MA 01609-2280) or c/o mwdorsey@ wpi.wpi.edu.

—Joan Killough-Miller

A Vital Connection for Job Hunters



As you browse through WPI's Web service, you're likely to come across Margaret Riley's constantly growing guide to job hunting and career resources on the Internet (it's in the Gordon Library section and on Margaret's own home page—**http://www.wpi.edu/~mfriley/jobguide. html**). The list developed by the Gordon Library circulation librarian has grown considerably since it was mentioned in the Summer 1994 *Journal*—and not just in length. It has also added thousands of new users and won growing recognition.

Riley and her expertise in Internet job hunting have been featured in stories in the *Scientist, Boston Business Journal* and *Working Woman,* among other publications. She has also been a consultant for a new book on Internet job-hunting tips by Joyce Lane Kennedy, who writes a syndicated column on career-related topics.

Riley says the list, which is part of a large set of subject-oriented Internet guides housed at the University of Michigan, is still the most comprehensive on the Net. She continues to update it monthly, a task that grows more and more time-consuming as use of the Net for job hunting and recruitment escalates.

"As people realize that other people are using the Internet as a job-hunting and recruiting resource, more and more people and organizations are setting up services," Riley says. "Many companies, as they join the World Wide Web, are including their job opportunities. Corporate recruiters are joining. The Internet in general (and especially the Web) is becoming the new place to look for a job."

Riley says she finds the information in her guide by personally scouring the Net and by subscribing to Internet mailing lists that announce new services. She also receives electronic mail from people who are creating new services and want to get into the guide. (She says she will not add companies that charge for job hunters to read their listings unless they make a reasonable amount of information available at no charge.)

She says she also receives many e-mail messages from around the world sent by users of her guide. While many people write to thank her for creating the listing, a great deal of the mail is from people who need help using basic Internet tools to find the information. "People are still learning the basics," she says. "Contrary to what many people think, most people are not Internet literate."

But it's not just individuals who are coming to grips with the vast sprawl of the Net, as Riley recently discovered. Governments, too, sometimes need to catch up. "I got a call from someone at the federal Office of Personnel Management," she says. "The committee that runs the federal job list has convinced OPM to change their procedures based on the amount of recruiting going on through the Internet.

"It was in large part because of my guide that they realized how far behind the federal government is. Because of that the OPM will be incorporating the use of the Internet in its application procedure, its recruiting procedure and several other of its practices."

—MD

Projects From Around the World Focus on Environmental Issues

By Angela Innamorati

Helping Solve a Garbage Disposal Problem in a Thai Slum

Dealing with garbage is a major problem in the Klong Toey slums of Bangkok. With infrequent municipal waste collection, residents are left to pile trash in huge mounds on roads and to dump it into the canals and drainage system. The result is water contamination, the proliferation of rats and cockroaches, and the rapid spread of disease.

"The problem is so bad, it takes less than a week for a recently cleaned water source to refill with trash," says Jason Anderson '95, who with Sandra Davis '95 spent seven weeks in Thailand last year examining the waste problem in Klong Toey and developing ways to help residents clean up their community.

The Interactive Qualifying Project, a finalist in the 1994-95 President's IQP Awards competition, was sponsored by the Duang Prateep Foundation, which is dedicated to helping improve the quality of life for slum residents. It was advised by John F. Zeugner, professor of history at WPI and director of the Institute's Bangkok Project Center.

Before traveling to Bangkok, the students did a literature search on solid waste management and learned about life in the slums. Once in Thailand they observed the daily activities of more than 1,000 families and talked to three influential nongovernment organizations to learn about potential strategies for getting slum residents involved in improving their surroundings.

Part of the garbage problem in Klong Toey can be traced to the inefficient city trash collection service for the slum area. The service consists of six people who must walk several miles each day carrying up to three tons of trash in wheelbarrows. Low morale among the collectors results in a high rate of absenteeism and poor service. In fact, Davis says, the government collects garbage in the slums an average of just two to three times a year. "They do it if an important person is scheduled to visit," she says.

Anderson and Davis say they believe the lack of interest in the garbage problem contributes to a general feeling of indifference and hopelessness on the part of slum residents. The students say residents respond to virtually any problem, from mounting garbage to AIDS, with the phase "Mai ben rai" ("It's no problem/It's O.K.")

The students set out to attack the garbage problem from a number of directions. For example, they mathematically analyzed the current garbage collection system and suggested ways it could be improved. They pointed out potential new disposal sites and mapped out a more efficient collection pattern.

They designed educational materials to encourage residents to play a more active role in cleaning up their community. The materials included posters that highlight proper garbage disposal methods and the importance of recycling, among other topics. They also created brochures and T-shirts that illustrate the connection between improper waste disposal and disease.

The students also made recommendations for a variety of low-cost clean-up methods aimed at reducing the improper disposal of garbage. These included the purchase of trash barrels and the fencing of proposed dump sites. They emphasized that these are the minimum steps that must be taken to begin turning the trash problem around.

"Although we would have liked to solve the problem completely, we had to be realistic," Davis says. "We hope we started the ball rolling and that the people who inhabit the slums will take a proactive stance in making theirs a better community."

Anderson says the project was "intense, intriguing and exciting. Not only did we develop and improve our presentation skills, we learned about tolerance and cultural diversity," he says. Davis says her experience in Thailand changed the way she interacts with the international students at WPI. "Everyone in Bangkok was so helpful and attentive," she says. "They went out of their way to help me get acclimated. I want to do the same for students who come to WPI from overseas. It's so important and takes so little effort, but it makes such a big difference."

"Cross-cultural encounters are the most vivid learning experiences," says Zeugner. "Watching Jason and Sandy grapple with their astonishment, frustration, confusion and elation was an educational experience for me."

Will Biogas Be a Viable Alternative to Firewood In Botswana?

Ahmed Al-Baiti '95 of Tanzania, William Herron (who has since transfered to the University of Alabama), and Corey Lewis '95 of Bloomfield, Conn., shared a common desire when they enrolled at WPI: they wanted to go to southern Africa to do one of their required projects. When they decided to travel together to the Republic of Botswana to do an IQP focused on that nation's energy problems, they found that they would first need to solve a more immediate problem—raising the money for the trip.

The students hoped to look for renew-

This page: Jason Anderson and Sandra Davis (in foreground) in the Klong Toey slum; Ahmed Al-Baiti, left, and William Herron in Botswana. Next page: from left, Antonio Delgado, Corinne Kachlert, Gail Concannon, Michael Conklin, Philipp Herget, Hanna Herharter of the Innichen Tourist Association, Kimberley Scofield and Dean Emeritus William Grogan in Innichen; from left, biologist Eduardo Cintron, Rafael Chavez and Susan Moriera prepare to fly with their pilot to Isla de Mona.

able energy resources Botswana might turn to in order to end its reliance on wood for cooking and heating and its dependence on imported oil and gas for diesel engines, appliances and lamps. The heavy use of wood is a special concern, because (coupled with a growing population) it is leading to the depletion of the nation's forests and endangering its land and water.

The students estimated that their expenses for the seven-week trip would run about $13,000 more than what the Institute could contribute. Seeking to raise the needed funds, they contacted local congressmen, small business owners, black organizations and energy groups. They also approached the U.S. and Botswana embassies. "It was a lot more difficult than we imagined to raise the money," Lewis says. "We found that people were interested in making contributions, but were skeptical because nobody else had yet done so. It was a vicious cycle."

The students also turned to friends and relatives for help. They even contemplated selling their stereo systems and cars to finance the venture. "It wasn't until then that people realized how serious we were and that we'd do it at any cost," Lewis adds.

To reduce their financial needs, the students reworked their expenses, cutting meals down to the bare essentials and asking J. Raheem Hosseini '89, director and general manager of Kgalagadi Resources Development Co. Ltd in Gaborone, Botswana, for help in finding inexpensive lodging.

It was then that the students received their first contributions. They came from W.A. Bland Addison Jr., associate professor of history, who co-advised the project with Tom Hartvig Thomsen, associate dean of student life and international student advisor, and Edward Clarke, professor emeritus of engineering and science.

"They started the ball rolling," says Al-Baiti. "After that, we called everyone back and asked again if they would help out. The response was quite a bit different this time." Among the contributions the students received were several corporate gifts, including nearly $2,000 from United Technologies.

Once they reached Botswana, the students learned more about the nation's disappearing firewood supply. They estimated that within a decade the country (78 percent of which is now covered by desert) would run out of fuel. "The people of Botswana were only addressing the problem with short-term solutions," Herron says. "For example, they were planting eucalyptus trees to use as firewood because they grow so fast."

After researching potential alternatives, the students recommended that Botswana use biogas as a cooking fuel and as a replacement for petroleum products (importing these products costs Botswana millions of dollars each year). Biogas, a mixture of methane, carbon dioxide and other gases, is produced by fermenting animal and human waste and vegetable matter.

The students say the waste from the nation's four million head of cattle alone could generate enough biogas to fill all of Botswana's energy needs. "Biogas is the most affordable renewable energy resource, and it can be readily produced in Botswana," Lewis says. "In addition, it is not harmful to the environment."

The project won the 1994-95 President's IQP Award. Despite the thoroughness of the student's research and recommendations, the Botswanian government is unsure about making the switch to biogas, Herron says. "They just aren't looking at the long-term effects of what they are doing. After all, why should they pay for biogas when they can get firewood for free? Still, the increasing ecological and energy problems the nation faces may change their attitudes."

Balancing Tourism and Cultural Preservation in the Tyrol

Innichen (San Candido), an isolated region of the southern Tyrol on the border between Italy and Austria, is known for its beauty and its skiing. Thanks to the work of six WPI juniors, it may also be known as the newest addition to WPI's growing global network of project sites. Last summer, Estado Aragua, Gail Concannon, Michael Conklin, Antonio Delgado, Philipp Herget, Corinne Kachlert and Kimberley Scofield traveled to Innichen to examine the feasibility of establishing a WPI project center there and to study the impact of tourism on the local economy.

The idea of establishing a project site in Innichen grew from a conversation in the summer of 1993 between William R. Grogan '45, dean emeritus of undergraduate studies, and Fabio Carrera '84, coordinator of WPI's Venice Project Center. The topics for the first two projects were suggested by David B. Dollenmayer, associate professor of German and coordinator of WPI's foreign language Sufficiency program.

"The area is extremely interesting historically," Grogan says. "Innichen was part of Austria until after World War I, when it was annexed by Italy. All of the town's 3,000 residents speak both Italian and German." Advance work by Grogan, Dollenmayer and Carrera led to an agreement by the town to provide the students and their advisors with housing at no cost. An office, complete with

photocopy and fax machines (not to mention a spectacular view), was also made available.

As part of their "bootstrap" project, Concannon, Conklin and Kachler set out to identify potential student projects in Innichen and to learn all they could about the region's history, culture and geography. They did extensive library research, conducted telephone interviews, and went door-to-door to talk to townspeople about their concerns. The result was a list of 29 potential projects, most of which would focus on environmental issues in the region.

"The town is interested in determining how growing traffic from tourists, whether hikers or mountain bikers, is affecting the local environment," Concannon says. Innichen's majestic hills have long been a lure for skiers. In recent years, interest in hiking and other outdoor activities has drawn vacationers to the region year-round.

For their project, Delgado, Herget and Scofield took an initial step toward addressing those concerns. They surveyed farmers, tourists and town officials to find out how these groups viewed the importance of the growing tourist industry and its potential impact on the 26 mountain farms that line the Innichberg (the slope above the town). They found that while residents and town officials believe tourism is beneficial to Innichen's economy, they fear that it may diminish the traditional Tyrolean culture.

"The attractiveness and uniqueness of the Alpine farms, if they are preserved, will provide an attraction for tourists and income for the Tyrolean town," the students noted during their presentation to the town. They recommended a number of ways to achieve a balance between tourism and cultural preservation, including running guided tours of a few farms combined with exhibits of traditional methods of farming, baking and craft-making, and developing a program that would enable visitors to live on a farm and participate in farm life for a period of time in exchange for a fee.

The team members made their presentations in German; most had completed a Sufficiency in the language to prepare for the projects. Delgado, a resident of Venezuela, presented his portion in Italian. The invitations to the event were printed in both languages, while the students' final reports were written in German and English. One of the projects, "Farming on the Innichberg: Preserving a Unique Culture," was a finalist in the President's IQP Awards Competition.

"These projects were among the best I've ever seen," Grogan says. Innichen mayor Edgar Passler also gave the students high marks. "We don't get many Americans here and sometimes they are not so nice," he says. "Your students have completely changed the opinion of the people here about Americans."

Solar Energy May Make a Puerto Rican Paradise More Livable

For the six biologists who spend their days studying rare fish, iguanas, sea turtles, stingrays, sharks, octopuses and other exotic animals, Isla de Mona, an island off of Puerto Rico, is a paradise. But it is a paradise that comes at a cost. Living conditions on the island are primitive. In part, that is because financial and environmental restrictions prevent the operation of the diesel generators that provide electricity for the biologists and two maintenance people for more than 10 hours a day.

Although the Puerto Rican government would like to improve the accommodations on Isla de Mona and provide electricity around the clock, their primary concern is the welfare of the island's nonhuman inhabitants. That's why the Departamento de Recursos Naturales y Ambientales asked Rafael Chavez '95 and Susan Moreira '95 to study the situation and recommend an inexpensive, waste-free and environmentally sound alternative to the diesel generators.

In addition to producing air pollution and creating the potential for a fuel spill, the generators are costly to operate and maintain. "It costs $600 for fuel and $1,200 to transport that fuel every two weeks," says Wilhelm Eggimann, professor of electrical and computer engineering, who advised the project with Anita Sheperd-Mendez, a co-advisor at WPI's Puerto Rico Project Center in San Juan.

To learn more about the problem, the students met with representatives of the Departamento de Recursos Naturales y Ambientales and with the researchers and staff on Isla de Mona. "They also spent several days at the research station to see firsthand how the biologists have to live and work," Eggimann says. "The facilities were rather primitive."

The students recommended that the island's electricity be generated with photovoltaics. "PV is versatile, economically feasible and ecologically safe in many applications," Moreira says. "It is a great way to generate power in geographic locations like the Isla de Mona, where the only free energy source is the sun."

The students developed four economic models that compared the cost of the diesel generators to three possible ways of implementing a solar-energy system. They found that although the initial installation costs of a PV system are high, the system would cost about a third of the amount spent on the diesel generators over a 20-year period.

"The solution they proposed made perfect sense. It considered economic, technological and environmental issues," Eggimann says. "There is a good chance that the Departamento of Recursos Naturales will actually install one of the proposed systems." The project was a finalist in the 1994-95 President's IQP Awards competition.

—Innamorati served as acting assistant director of the News Service during part of 1994.

Flushing Soils Clean of Metals

Among the most difficult problems environmental engineers face is treating hazardous waste that has been spilled onto, leached into, or buried under the ground. Once released into the earth, wastes like organic solvents and heavy metals can become bound to the soil or slowly disperse until they contaminate groundwater. Often the only way to recover the waste and treat the soil is to dig up huge quantities of earth and cart it off to treatment sites or dumps, an expensive proposition.

With funding from the Environmental Protection Agency, Robert A. D'Andrea, associate professor of civil engineering, and James C. O'Shaughnessy, professor of civil engineering, have been conducting laboratory tests of a technique they've developed for removing metal wastes from soils on-site by flushing them out with solutions containing chelating agents. These are chemicals, like citric acid and EDTA, that can bind tightly to metals and keep them in solution. Some of these agents are also used by physicians to treat heavy-metal poisoning.

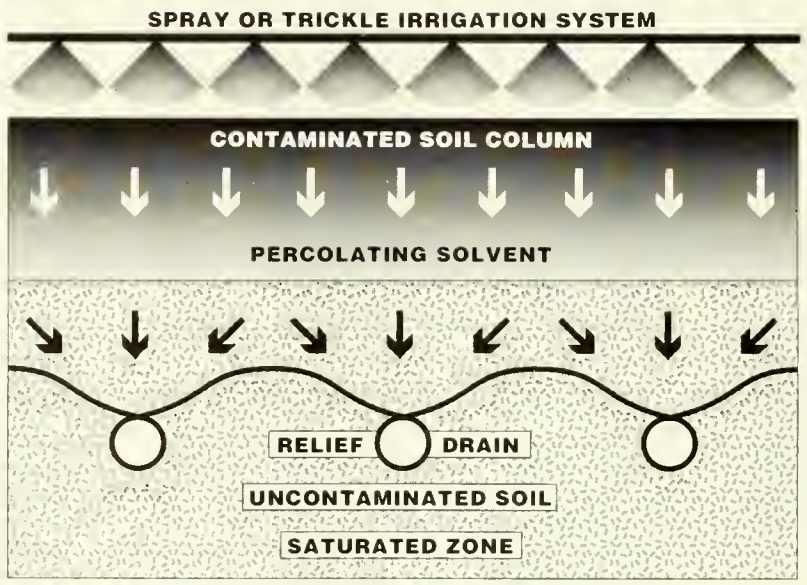
"The EPA is interested in our technique because it is a possible remediation method for the Lipari Landfill in New Jersey, a major Superfund site," D'Andrea says. "It may also prove useful at a number of other Superfund sites in Northern industrialized states that have similar soils and long histories of manufacturing and disposing of metal wastes."

The permeability, or hydraulic conductivity, of the soil is a critical factor in determining whether or not the technique will work. D'Andrea says the conductivity of soil can vary by more than 10 orders of magnitude, from dense clays that are almost impermeable to loose gravel that is highly permeable. "That's more variance than you will find in just about any other engineering parameter," he says.

The soils that are most likely candidates for flushing are mixtures of mainly sand and gravel, with small amounts of fines, a grain-size distribution that is often the result of glacial deposition. These soils are reasonably permeable to water and are also capable of latching onto heavy metals before they wash down into the groundwater.

To conduct their tests, D'Andrea and O'Shaughnessy gathered numerous samples of this type of soil from various sites around New England. After preliminary evaluation, a soil deemed to have the greatest potential for successful treatment was chosen. The soil, obtained from a site in Worcester, was artificially contaminated by treatment with solutions containing varying concentrations of metal salts. It was then placed into tall plexiglass columns.

JANET WOODCOCK



O'Shaughnessy, left, and D'Andrea with some of the permeameters they used to test their technique for flushing heavy metals from soil. The diagram by graduate student Alton Day Stone shows how a chelating agent solution would be sprayed onto contaminated soil and allowed to percolate down to drains.

Because previous research had shown that columns filled with soil were prone to clogging when repeatedly flushed with water, the researchers also conducted tests with similar soil packed into small plexiglass cubes. The cubical containers, called multidirectional hard-walled permeameters, permitted the direction of the flow of water to be varied by 90 degrees to reduce the chance of clogging and to enable the researchers to investigate metal precipitation. The permeameters and an associated piping system were based on an apparatus designed as part of a Major Qualifying Project by John T. Germain '76, now a principal research associate at MIT.

In tests with the columns and cubes, D'Andrea and O'Shaughnessy flushed the soil multiple times with plain tap water and with solutions containing various chelating agents. They found that each of the six metals they tested (cadmium, copper, chromium, lead, nickel and zinc) reacted differently to the flushing.

Copper, for example, was unaffected by the water rinses, but could be completely removed from the soil with repeated rinses with an EDTA solution. Up to 80 percent of chromium was removed in some trials with tap water rinses alone, while the addition of the EDTA solution removed only an additional 1.5 percent.

To put this technique into practice in the field, D'Andrea says, a temporary barrier would be constructed to surround the contaminated soil. A solution of chelating agents would be trickled onto the soil surface while wells would pump the water collected from underdrains beneath the ground, drawing the chelating agent solution through the soil.

For his thesis, master's degree candidate Alton Day Stone proposed the use of this method to treat contaminated soil at a site in Cambridge, Mass. "In this study, Stone applied the laboratory results to show that more than 50 percent of the metals in the soil could be recovered," D'Andrea says. "Though we wouldn't achieve complete removal for all metals, it should be possible to reduce the metal concentrations to safe levels—and levels that meet state standards—in a relatively cost-effective way."

Tackling the Scourge of Heavy Metals

The first three stories in this edition of "Investigations" profile WPI teams that are developing three quite different ways of dealing with the problem of heavy metals in the environment. Unlike the many manmade pollutants that have contaminated the Earth, heavy metals are naturally occurring substances. Many, such as chromium, nickel, cobalt and copper, are actually necessary in small quantities to sustain life. But when these same metals are released into the environment in large quantities as waste from manufacturing and metal-plating plants, as components of agricultural pesticides, in sludge from sewage treatment plants, in products like batteries, paint and electrical equipment, and in the exhaust from gasoline- and diesel-fueled vehicles, they can become a serious threat to health, causing acute and chronic toxicity and even cancer.

Federal environmental laws and regulations now prohibit the wholesale release of metal wastes into the environment and make manufacturers liable for the safe and responsible disposal of any waste they generate. These laws, plus a growing awareness that treating waste and recovering the metals can often be more cost-effective than buying new raw materials, has focused attention on finding more effective and economical ways to extract metals from the waste stream.

But even as industry works to keep heavy metals out of the environment, vast quantities of waste, the legacy of more than a century of industrial activity in this country, lie buried in thousands of underground sites, slowly releasing metals into the soil and groundwater. Recovering these wastes and treating contaminated soils—a major focus of the federal Superfund program—is proving to be a difficult and extremely expensive undertaking.

Evolutionary Trick May Provide an Economical Heavy Metal Treatment

Within the cells of all living things are tiny quantities of heavy metals. Elements like iron, copper, selenium and zinc are critical components of enzymes that enable organisms to carry out such life-sustaining functions as the transport and storage of oxygen and the metabolism of food. To keep these valuable substances from washing away into the lower reaches of the earth, fungi, molds and bacteria in the top layers of soil capture them and keep them in circulation.

Research by Ted Crusberg, associate professor of biology and biotechnology at WPI, has shown that the same physiological processes that enable these organisms to absorb small quantities of metals may also protect them from the toxicity of much larger concentrations of these elements. This previously unknown defense mechanism, in turn, may become the basis for a simple, effective and economical way of treating heavy metal waste.

For several years, Crusberg has been studying the ability of a *Penicillium* mold to entrap heavy metals. Initially, the work focused on beads made from the cell walls of microbes from which the living matter had been chemically removed (*WPI Journal*, Winter 1990). More recently, Crusberg has started experimenting with living cells. "I've found that the living organisms are easier to work with," he says. "But more important, they are also 12 times more effective at absorbing heavy metals."

Using various analytical techniques, including electron microscopy, Crusberg and his team (which currently includes eight undergraduates and two graduate students) have shown that *Penicillium* uses an enzyme secreted through its cell membrane to create an environment in which metal ions bind to phosphate ions. The resulting metal phosphates are trapped within the periplasm, a fluid layer that lies between the cell membrane and cell wall in fungi. The process, called biomineralization, is similar to the way coral cells build their protective shells and to the way bones are formed.

"This is really an interesting protective mechanism," Crusberg says. "The metals never reach the interior of the cell, so the organism is in no danger. The only problem is that as the cells growing in culture trap more and more of the metal, they get very large and heavy and will ultimately settle to the bottom. Then, getting adequate oxygen and nutrients to the cells becomes a problem."

Studies in Crusberg's lab have shown that the *Penicillium* mold is highly effective at absorbing virtually any heavy metal. It also survives well in even highly concentrated metal solutions. In addition, the mold is easy to grow in a continuous process.

The cells tend to cluster into pea-sized beads that can be freeze-dried and later revived. The beads are easy to keep suspended in solution, thus eliminating the need to immobilize the cells in columns or grow them into mats, techniques that are required for other types of biological agents used in waste treatment.

"It should be possible to send a small quantity of freeze-dried *Penicillium* beads to an industrial site," Crusberg says. "The beads would be placed in a bioreactor, and from that initial supply, the company could grow all the fungus they need. That's another major advantage of living cells over dried cell walls."

The fungal beads, which Crusberg calls biotraps, should prove an effective and low-cost method for treating industrial waste streams containing heavy metals. The beads, once they become saturated with metal ions, could be removed from solution and burned in a kiln. The only thing left behind would be the metals, which could be recovered and reused.

Another possible application for the biotraps is the treatment of water contaminated with radioactive metals (including uranium and plutonium) from nuclear reactors and nuclear weapons plants. "These wastes are now very difficult to treat," Crusberg says. "I've already had some preliminary talks with people at some of the national nuclear laboratories about testing this application."

Crusberg has also had discussions with engineers at the Worcester wastewater treatment plant about testing the organism's ability to remove copper from the treated water before it is discharged into the environment. "Copper leaching from water pipes in the home is a major problem in the Northeast, where the leaching is significantly enhanced by acid rain," he says. "The copper eventually finds its way into municipal wastewater. There are EPA regulations in the works that may require municipalities to remove that copper during wastewater treatment, before it is discharged. Biotraps may prove to be an economical way of doing that."

In addition to studying how the *Penicillium* mold goes about trapping heavy metals, Crusberg has been working to give that ability to other microorganisms. He and his team have obtained the gene that produces the enzyme responsible for heavy metal bio-

mineralization. The next step will be to use genetic engineering methods to transfer the gene to other bacteria, fungi or molds. "We should be able to give this resistance to almost any microorganism," he says.

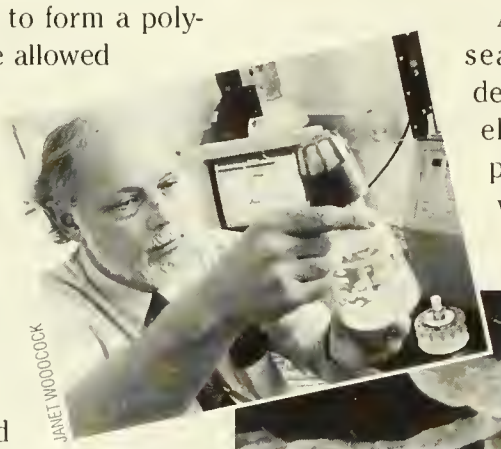
Pillared Clays May Stack Up Against Heavy Metals

Clay is a component of soil made up almost exclusively of very fine particles. These tiny shards of mineral matter bind readily to metallic ions, making them good candidates for filtering heavy metals from industrial waste streams. But the fine grain structure of clays also renders much of their interior surfaces inaccessible for adsorption. To date, this has limited their utility for waste treatment.

JANET WOODCOCK

With a grant from the Environmental Projection Agency's Risk Reduction Engineering Laboratory in Cincinnati, Yi Hua Ma, professor of chemical engineering, and Alfred A. Scala, professor of chemistry, are experimenting with a technique that may overcome this shortcoming. The technique involves creating tiny pillars that force apart the layers in clay, creating channels through which wastewater can flow. Working with Ma and Scala on the project is Danyan Li, a postdoctoral researcher whose Ph.D. dissertation at Michigan State University focused on pillared clays.

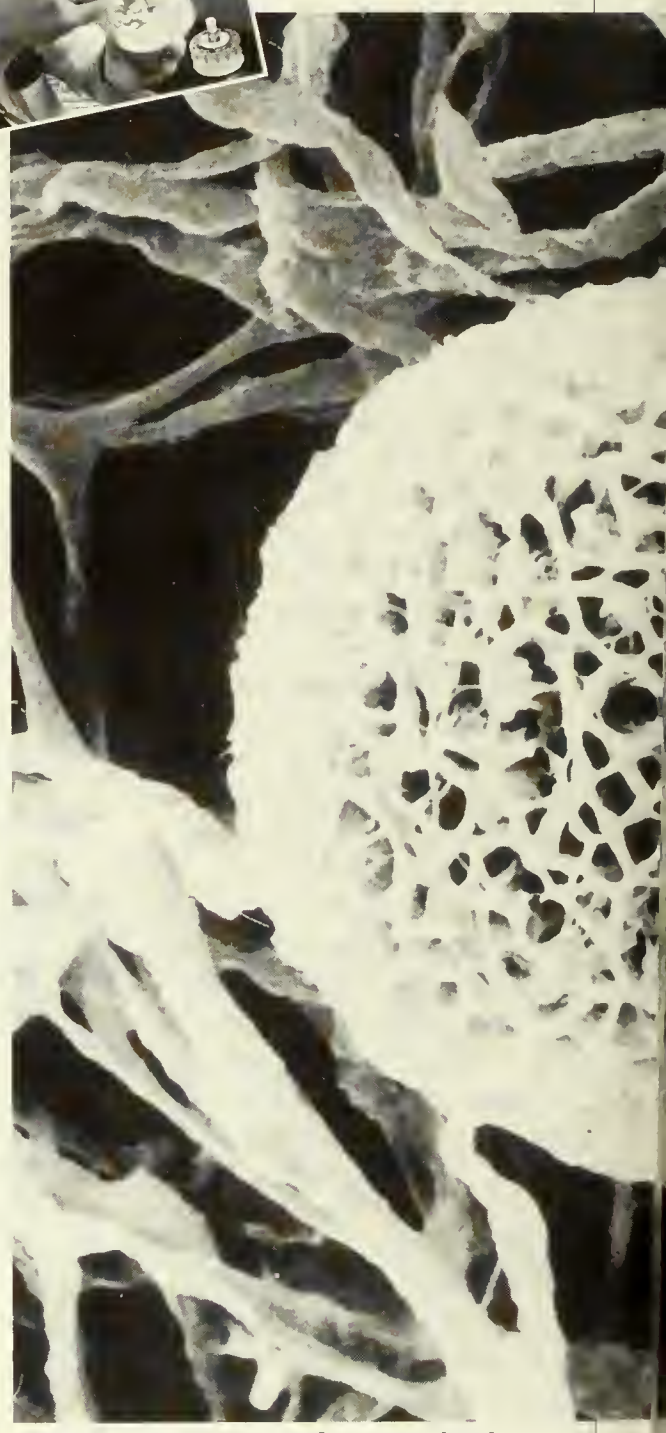
To create a pillared clay, the researchers mix natural or synthetic montmorillonite clays with a solution containing inorganic polymeric cations (positively charged ions capable of linking together to form a polymer). The clay particles are allowed to settle out of solution, forming layers. When the clay samples are baked at a high temperature, the polymeric ions form pillars that become chemically bound to the clay particles, pushing the clay layers apart.


JANET WOODCOCK

Once they have created pillared clays, the researchers use a variety of techniques, including electron microscopy and x-ray diffraction, to study their physical properties. These include the size of the channels created by the pillars and the total surface area available for adsorbing heavy metals. "Our two departments have many years of experience using these techniques to study other porous materials, most notably zeolites, that can be used as ion exchangers," Ma says. "It was this expertise that led us to realize that pillared clays may prove effective as exchange agents for heavy metals."

In addition to the structural characterization, Ma, Scala and Li will use fixed beds of pillared clays to measure their effectiveness in removing a range of heavy metals from water. They will also determine whether they can get the clays to release the heavy metals in exchange for benign ions like sodium, making it possible to regenerate the clay beds and recover and reuse the metals.

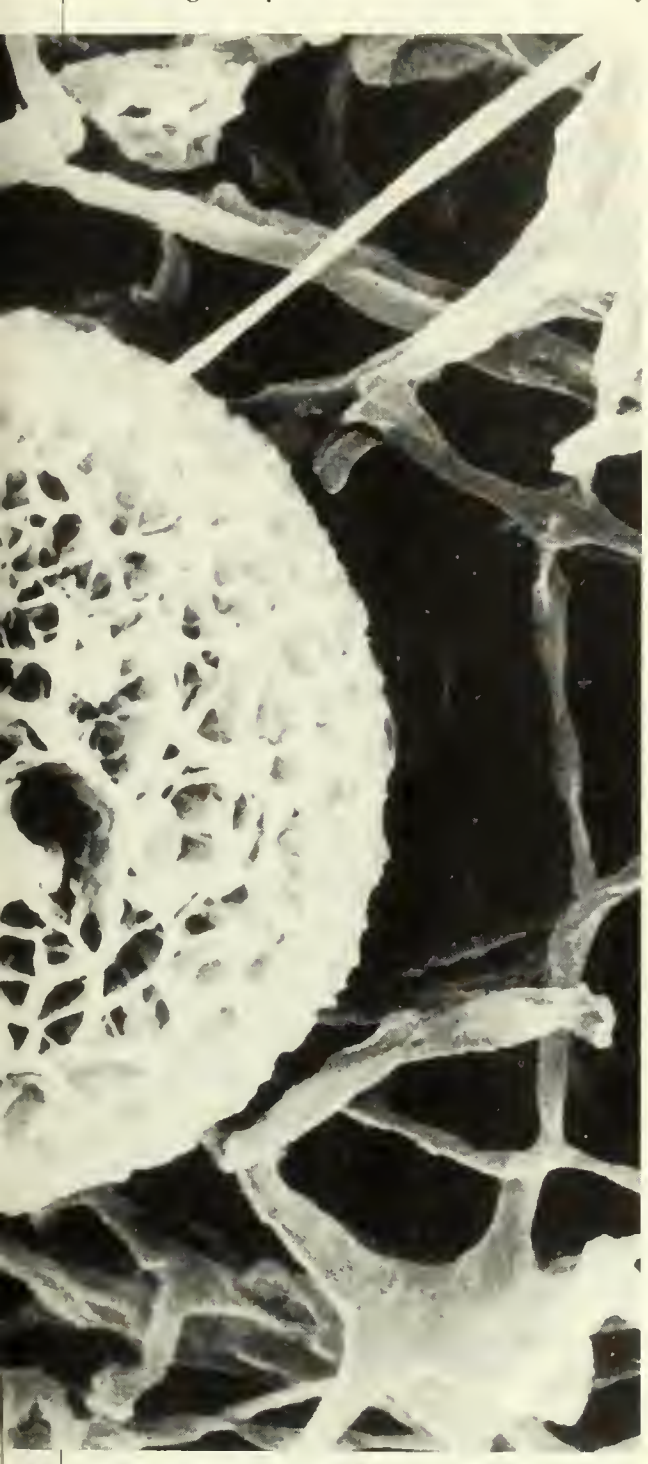
As part of their research, the team will develop computer models to simulate the processes that occur when the clays adsorb and release the metals. The models will help the researchers determine how to optimize the adsorption of the pillared clay systems. "These models



Above left, a photomicrograph of a pillared clay. Inset, from left, Ma, Li and Scala. Center, a 40-micrometer sphere of copper phosphate that has formed in the mycelia of a *Penicillium* fungal bead. Inset, Crusberg. Far right, a scanning laser beam captures dye as it disperses in a simulated ocean environment. Inset, from left, Baird, Johari and Jumper.

should be generally useful in evaluating and optimizing processes involving absorbents," Ma says.

"If they prove successful," Scala says, "pillared clays could be used to treat concentrated metal wastes produced by manufacturers like metal platers, lowering or eliminating the cost of disposing of these materials. By enabling companies to recover metals they



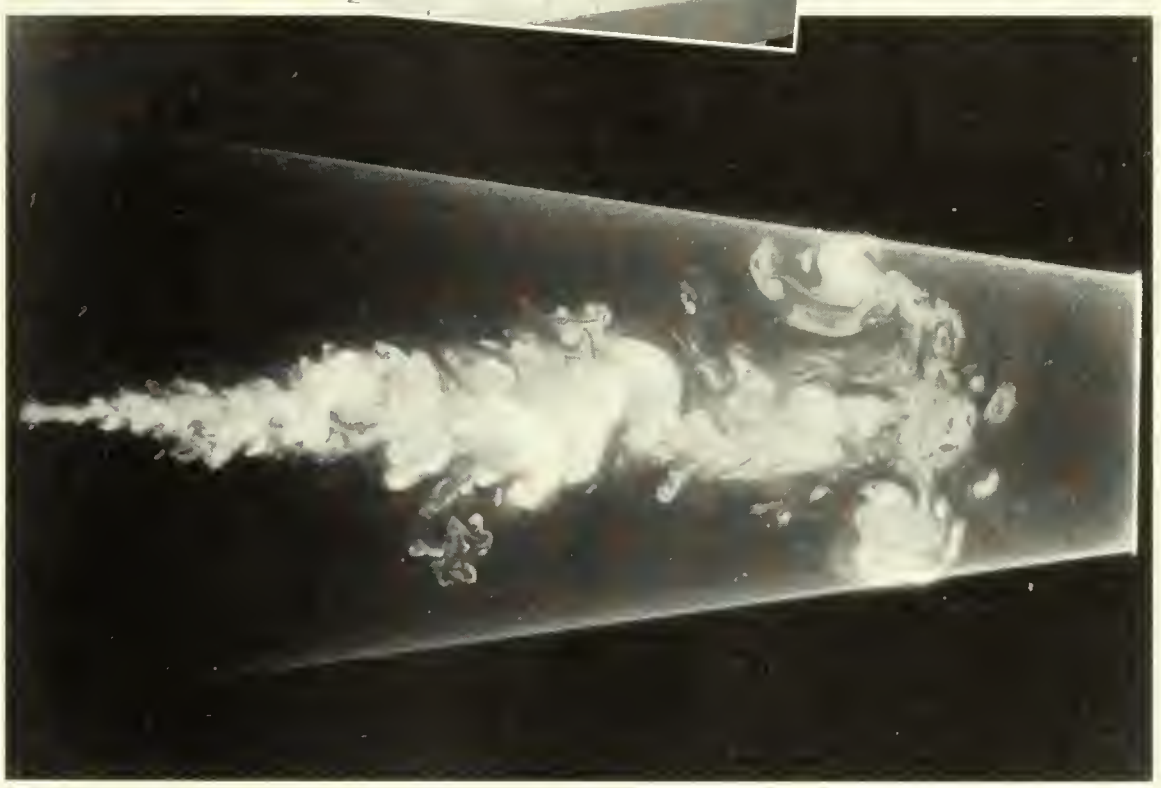
now dispose of, the technique should reduce their raw material costs and make their operations more efficient and competitive."

Finding Out How Deep-Sea Fishes Follow Their Noses

Hundreds of meters beneath the surface of the ocean lies a strange, alien world. Here, in a still, cold, pitch-black realm, live exotic species of fish well-suited for life in a watery desert where the main sources of food are ultimately derived from more fertile waters far above, and where encounters with other creatures—including others of one's own species—may be few and far between.

In this environment, a fish's most valuable asset may be its nose, says Ronald C. Baird, director of corporate relations at WPI and an affiliate associate professor of biology and biotechnology. "It has long been known that a number of fishes use pheromones to attract mates and that the chemical sense is important to them," Baird says. "I have been interested in deep-sea ecosystems, and it is

MICHAEL DORSEY



clear that in those environments, chemical reception must play a very important role in the life of many of the species found there."

Baird, who holds a B.S. in zoology from Yale, an M.A. in zoology from the University of Texas, Austin, and a Ph.D. in biological oceanography from Harvard, has taught and written extensively on deep-sea fishes, oceanic ecosystems and natural resources management. He is currently a courtesy professor of marine science at the University of South Florida's Marine Sciences Institute, where he taught for eight years, a member and past chairman of the National Sea Grant Review Panel, and the National Oceanic and Atmospheric Administration (NOAA) representative to the Gulf of Maine Regional Research Board.

In the mid-1980s, when Baird became interested in the olfactory sense in the hatchetfish and other deep-sea fishes, he decided that to understand how these fish use their noses to locate food and mates, he would first need to better appreciate how chemicals disperse in the open ocean. After developing some rudimentary mathematical models, he realized that he would need the help of someone versed in fluid dynamics and computational techniques.

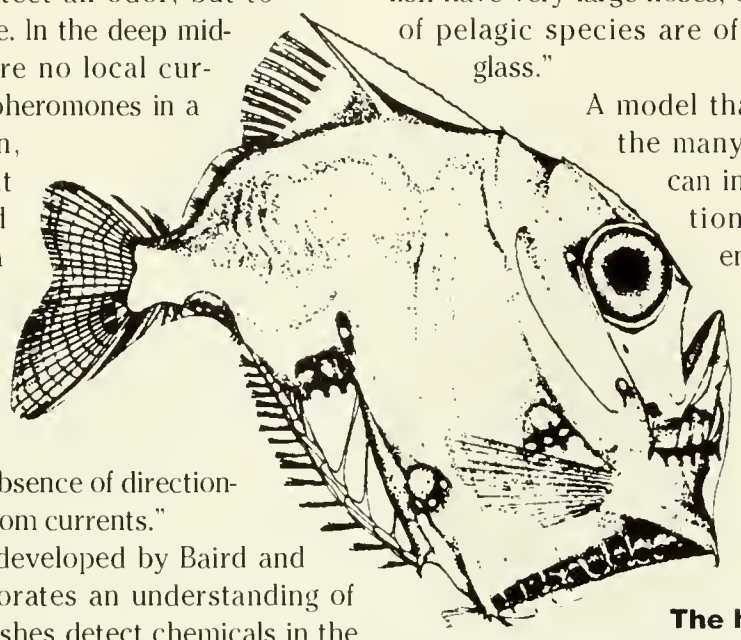
That someone was George Y. Jumper, then associate professor of mechanical engineering at WPI and now senior aerospace engineer in the Aerospace Engineering Division of the U.S. Air Force Phillips Laboratory at Hanscom Air Force Base in Massachusetts. Jumper brought to the table a broad technical background ranging from chemical engineering and physical gas dynamics to target acquisition and system optimization theory honed in his work for the Air Force.

"I had originally asked George to improve the modeling of the pheromone dispersion in the ocean, which alone did not seem to yield meaningful results," Baird says. Jumper says he found himself haunted by the inability of the model to explain the obvious ability of the hatchetfish to find mates.

"Finally, one night I began to dream about spherical molecules moving about in space, hitting each other and the walls of their container," Jumper says. "The spheres then turned into hatchetfish and I awoke with a start. I realized that pheromone dispersion alone could not explain the prob-

lem, because the fish were also moving—a lot faster than the pheromones. The next day I applied the equations for the collision of molecules against a wall to the problem of fish swimming into a patch of pheromones, and it cracked the problem."

In their work, Baird and Jumper also made use of encounter theory, which attempts to explain how organisms come in contact with each other. "We thought this would be a good starting point for a theoretical analysis of the problem," Baird says, "since fish have to not only detect an odor, but to locate its source. In the deep mid-ocean, there are no local currents to move pheromones in a linear fashion, creating a scent trail. So we had to develop a new theory about how an organism might locate the source of an odor in the absence of directional information from currents."



The hatchetfish *Sternoptyx diaphana*, resident of a strange deep-sea world.

The model developed by Baird and Jumper incorporates an understanding of how deep-sea fishes detect chemicals in the water, gained through knowledge of the physiology of fish olfactory systems; estimates of the abundance and vertical distribution of a number of these species, derived from trawl studies conducted by Baird and others; and data on how chemicals disperse in deep water, derived, in part, from diffusion theory and studies that tracked the movement of dye released hundreds of meters deep in the ocean. The model was enhanced with the help of Hamid Johari, assistant professor of mechanical engineering, who joined the research team in 1993. He brought a wealth of knowledge about diffusion processes and experimental techniques to the mix.

The analysis revealed that one of the most critical factors in determining whether a fish is likely to locate a potential mate or meal (and whether, in turn, a species is likely to survive) is a variable they call the perception distance. This is the distance at which a fish is able to first recognize and locate a target organism. The probability of successful encounters with such targets increases exponentially as the perception distance increases.

"Any factor that can change the perception distance can have a profound effect on the probability of encounter," Baird says. "To enhance reproductive success, for example, females of some species release pheromones into the water, while the males have developed inordinately elaborate olfactory organs to increase their ability to pick up the pheromone scent.

"Animals encounter things in real-time and 3-D," Baird says, "so the physics of real-time, 3-D encounter is a critical dimension in understanding aquatic ecosystems. It begins to explain why organisms look the way they do—why, for example, some male deep-sea fish have very large noses, or why the larva of pelagic species are often as clear as glass."

A model that accounts for the many variables that can influence perception distance and encounter probabilities can be extremely complex and require considerable computer power to run, Baird says. For this reason, with funding from the Advanced Research Projects Agency, Baird, Jumper, Johari and mechanical engineering graduate student Michael J. Rider are adapting encounter algorithms to run on high-performance, massively parallel computers in collaboration with the Enterprise Computing Institute (formerly WPI's Center for High Performance Computing).

In other work, the researchers plan to begin gathering new data on chemical dispersal in simulated aquatic environments using a sophisticated water tunnel and other equipment in the Fluid Dynamics Laboratory in Higgins Laboratories.

The research on deep-sea encounter theory is just one aspect of a multidisciplinary program in ecological engineering at WPI that began in 1989 when the Institute received a multiyear grant from the Rodney Hunt Co., a maker of water- and sewage-control equipment in Orange, Mass. The grant has supported educational and research programs that apply the tools and techniques of engineering and computer science to environmental and ecological problems.

"This program grew from the recognition that there are a host of problems in these fields that are so complex they don't lend themselves to one-discipline solutions," Baird says. "Ecologists are generally not well-versed in engineering and computer science. At the same time, engineers and scientists have skills, exciting technology and computational methods that can be applied to ecological problems. As an oceanographer and ecologist, I saw all of this expertise around me at WPI and I thought, 'Let's see if we can bring these people together to work on a problem of real ecological interest.'"

To date, more than 10 graduate and undergraduate students have worked on research projects through the ecological engineering program. Their work has contributed to four papers in top ecological and oceanographic journals and to several invited presentations at national scientific meetings.

"These are not, by and large, students who intend to pursue careers in the environmental field," Baird says. "Rather, they are using engineering theory and tools they will eventually employ in their careers and applying them to real problems that just happen to have an ecological thrust. In the process, they're gaining a new appreciation for the environment. That's the real goal of this program—to expose engineering students to ecological issues.

"In the next century, the environment may surpass the economy as our principal national concern. Clearly, all engineers and scientists will find themselves dealing with issues that relate to the environment and the global environmental implications of technology. Just as important, future engineers and scientists must understand that they will be called upon to play important roles in solving the environmental problems we face."

How Poor Decisions Can Add Up to Global Problems

In 1982, James K. Doyle, assistant professor of social science and policy studies, earned a bachelor's degree in environmental sciences at the University of California, Berkeley, and set out to help solve the world's environmental problems. But he soon made a fundamental discovery that would change the course of his career.

"I realized that the primary cause of these problems is human behavior," he says. "I had thought I could have a fine career fixing environmental problems, but each time a problem was fixed, people would turn around and create a new one. So I decided

to go to the source and find out how people think about the environment and how they make the decisions in their daily lives that contribute to environmental problems."

Doyle went back to school and earned a Ph.D. in social psychology at the University of Colorado in 1991. Since then he has been studying judgement and decision making, particularly the kinds of decisions individuals make that concern risk to themselves and risk to the environment. As an example, Doyle points to the risk people face from exposure to radon gas in their homes.

Working with the Environmental Protection Agency, Doyle studied the results of a campaign in the Washington, D.C., area to encourage people to purchase and use reduced-price test kits. "We found that about half of the people who went to the trouble of buying the kits never sent them in for testing," he says. "Of those who did, only about half retested, which is recommended. Those whose kits measured more than 50 picocuries per liter were sent a free kit for retesting. Half of those never came back. Only a few percent of people with a radon problem followed through to correct it.

JANET WOODCOCK

Doyle: going to the source.

"Before this study, the EPA had focused a lot of its efforts on getting people concerned about the risk of radon. But that's not enough. Dealing with a radon problem is such a long and technical process, most people just can't make it all the way through. So we suggested to the EPA that the time to get people involved is when houses turn over, because then there are brokers and other professionals to make sure things get done. With that approach, more than half the people with radon problems correct them."

"The environmental movement would like us to think globally, but as a social and cognitive psychologist, I don't think we now have or will soon develop the capacity to do that."

In another study, Doyle tried to assess whether people are accurate judges of the way some risks, like those tied to radon exposure, accumulate over time. "For example," he says, "if you live in a flood plain, the chance of a hundred-year flood occurring in any one year is one in a hundred. If you live there 25 years, the odds of at least one such flood rise to 22 in a hundred. If people don't understand that, it might explain why so few buy heavily subsidized flood insurance.

"Previous studies had concluded that people don't buy the insurance because they greatly underestimate how risk accumulates. We found that people are better at making such estimates than they'd been given credit for, but they don't buy the insurance anyway. They understand the risk and they worry about it, but these feelings get lost in the complications of everyday life. If they're having trouble getting jobs or feeding their families, flood insurance simply goes to the bottom of the priority list."

While people can sometimes think rationally about how risk accumulates, they are less clearheaded when it comes to quantifying how much they value the environment, Doyle has found. "It is easy to get people to say they value the environment, but it is much more difficult to get them to say exactly how much they value it," he says.

"If you ask them how much they'd be willing to pay on their water bill to clean up a toxic landfill leaking chemicals into the groundwater, they might say $10 a month. If you ask them how much they'd pay to clean up five landfills, they'd still say $10 a month. In your methodology, you have to be able to deal with problems like these. You also have to be wary of trying to get a value out of people when there is no value to be gotten until you ask the question."

Often, people's impressions about the environment and about risk are shaped by their own biases. For example, a recent IQP advised by Doyle showed that people tend to believe that larger animals, animals that are the most similar to humans, and animals unlike those they see every day, are the most likely to be endangered. "People have trouble imagining that an insect can be endangered," he says.

Often, biases are shaped or fueled by reporting in the media, Doyle says. For example, people tend to overestimate their risk of dying from causes that are heavily reported (murder, car accidents) and underestimate the risk from lesser-reported causes (diabetes, cancer). A current IQP is looking at whether people's concern over global warming is shaped by the impressions they get from the media concerning how much disagreement there is among climatology experts.

"There is substantial disagreement over minor points, such as which countries will be most affected, but there is almost complete agreement that global warming will happen over the next century," Doyle says. "But do people mistake the quibbling over details for disagreement on the big picture?"

Given the limitations of the human mind, are people up to the task of managing the global environment? "I'm certain that right now, we are not up to the task," Doyle says. "We have limits on our working memory, limits on the ways in which we can perceive the world, and limits on our judgement and problem-solving abilities that make it difficult for us to comprehend complicated, massively interconnected systems, let alone manage them. The environmental movement would like us to think globally, but as a social and cognitive psychologist, I don't think we now have or will soon develop the capacity to do that."

Is there an alternative? Doyle says rather than trying to manage the environment on a global scale, environmental scientists should focus on trying to get people to make better decisions in their own lives—to help them see that their actions, while seemingly inconsequential, help contribute to problems on a global scale. "It's the idiosyncrasies of our minds and the way we think that cause us to make bad decisions," he says, "and all these little everyday decisions add up to things like global warming, ozone depletion and species extinction."

—Michael Dorsey

STEWARDS FOR A

Many WPI graduates have found that helping protect the environment can make for an exciting and rewarding career.

By David Brooks, Allison Chisolm, Diane Benison, Michael Dorsey, Joan Killough-Miller and Ruth Trask

Illustration by Robert G. Cuoco

In the few short decades since the modern environmental movement began, some major achievements have been recorded. In this country, these include the creation of the Environmental Protection Agency and a host of other federal, state and local government bodies dedicated to environmental preservation; the passage of myriad laws and regulations governing water quality, land use, and the release of hazardous materials into the environment; and a sea change in public attitudes about the value of protecting the natural world.

As a result, today we live in a cleaner and safer world. But the battle to protect the environment is far from over. Important threats remain to our air, water and land. Huge quantities of toxic materials still lie buried underground all over the country, a threat to human health and the fiscal health of those who may unwittingly purchase polluted land. And industry must still grapple with the best and safest ways to deal with the hazardous byproducts of manufacturing.

None of this is news to the several hundred WPI alumni who have built careers in various aspects of the environmental field. In the pages that follow, we invite you to meet just a few of these talented men and women.

These eight stories were reported by staff writers Michael Dorsey, Joan Killough-Miller and Ruth Trask, and by David Brooks, a photographer and writer who lives in Warren, N.H., Allison Chisolm, a Worcester-based freelance writer, and Diane Benison, a former newspaper editor who writes regularly for the *WPI Journal.*

Small Planet

Hank and Paula Nowick Help Companies Save Money and Protect the Environment

In 1959, when Henry ("Hank") Nowick '56 began his career as a process engineer at Monsanto Chemical Co., protecting the environment was not a major focus for the chemical industry. Few environmental laws and regulations were yet in effect, and the impact of pollution on the environment and human health was not well understood. But all that would soon begin to change.

The publication of Rachel Carson's *Silent Spring* in 1962 alerted the world to the dangers of environmental pollution by pesticides, and in the process launched the international environmental movement. The first Earth Day in 1970 demonstrated the growing popular concern over pollution and environmental degradation, a concern that helped fuel the creation of the Environmental Protection Agency and the subsequent passage of landmark environmental protection laws, such as the Resource Conservation and Recovery Act and the Clean Air and Water acts, over the following two decades.

Today, a different sort of environmental revolution is taking place. Where the environmental movement of the 1970s and 1980s grew primarily from a desire to clean up the world's air, water and soil, and to find safer and more reliable ways to dispose of the products of our industrialized society, today there is a growing realization that protecting the environment can be good business.

More and more, companies are looking for ways to reduce their production of waste and to reuse hazardous materials—strategies that not only reduce the need to dispose of chemicals, but lessen the risks involved in storing and handling these materials. The potential for significant savings and improved safety are motivating many companies to accelerate their environmental efforts.

Nowick says his 35-year career in chemical engineering has been greatly influenced by the environmental movement. When he joined Monsanto in 1959, he was a technology specialist whose primary responsibilities were improving the manufacturing processes for existing products and bringing new products developed in Monsanto's laboratories into full-scale industrial production. He also became involved in starting up new chemical production units in Mexico, Spain, Italy, Germany and England.

In recognition of his contributions to the company, Nowick in 1979 was one of a handful of employees offered a full-year academic assignment at a university and in a field of his choice. He elected to study the emerging field of environmental engineering at the University of California at Berkeley.

"My years of varied industry experience gave me a perspective that many political-action environmentalists didn't share," Nowick says, "namely, that American industry was run by intelligent, well-meaning and caring citizens, like me, who had been unaware of the long-term impacts that new products and their by-products might have on the land, air and water. The solutions to these problems required intensive study and strategic planning, not sloganeering and name-calling."

When he returned to Monsanto, he was assigned to develop a coordinated hazardous waste management program for the company's Springfield, Mass., plant. In that job he developed training programs, conducted environmental audits for several Monsanto plants, and designed programs that enabled the company to meet environmental regulations in a cost-effective manner.

He also became corporate Monsanto's leading public speaker, concentrating primarily on environmental issues and industry compliance with government regulations. And he was a charter member of the Massachusetts Hazardous Waste Facility Site Safety Council, one of several boards on which he has served over the years.

At the many national conferences Nowick attended, he was introduced to the new revolu-

DAVID BROOKS

Hank and Paula Nowick, founders of Nowick Environmental Associates. After a 35-year career with Monsanto, Hank Nowick set out on his own. The firm he and Paula created helps companies comply with environmental regulations and reduce their production of hazardous wastes.

"My years of varied industry experience gave me a perspective that many political-action environmentalists didn't share, namely, that American industry was run by intelligent, well-meaning and caring citizens."

tion in environmental engineering. He learned that the most effective—and economical—way to tackle hazardous waste is to produce as little as possible. "The idea was," he says, "wherever possible, to reengineer your product and processes so as to minimize hazardous materials. Engineers were being asked to design more efficient processes, substitute materials, recover, recycle, and create new uses for by-products."

At Monsanto, for example, Nowick decided there had to be an alternative to paying between $50 and $300 per 50-gallon drum to dispose of waste resins generated at the plant. Drawing on his contacts at other chemical plants, he discovered that Polaroid was faced with similar costs for disposing of waste solvents. By commingling Monsanto's waste resins with Polaroid's waste solvents, Nowick was able to generate a fuel that could be sold to companies that produce concrete shale aggregate, replacing the more expensive petroleum-based fuels they were using. "That initiative produced hundreds of thousands of dollars of savings for everyone," Nowick says.

After taking early retirement from Monsanto, Nowick entered the consulting business in environmental engineering and founded his own company, Nowick Environmental Associates, in January 1994. His wife, Paula, is vice president of the firm. A major objective of the company is to help industries that process or handle hazardous chemicals, or that create hazardous by-products, comply with complicated state and federal regulations.

"I read the *Federal Register* every day," Nowick says. "It enables me to keep my clients abreast of amendments to environmental regulations, pending legislation, pertinent legal interpretations and current laws that may affect them. This is an ever-changing, ever-challenging field."

Because each state can add more stringent amendments to the federal law, companies doing interstate business must comply with many variations. "We recently trained workers in an Arizona-based company on the mandates they must follow to avoid violating federal, Massachusetts and Arizona environmental regulations," Nowick says. "The sessions took eight hours, including certifying exams."

Nowick presents training and certification programs in a wide variety of environmental topics. His largest training group included 993 Air National Guard reservists at Westover Air Reserve Base in Chicopee, Mass. "It took 32 sessions to train everyone," Nowick says. "I also produced a video to train absentees or newcomers. By the end of that assignment, I could give a five-hour training session with no notes."

In its first year of operation, Nowick Associates has developed toxic use reduction plans for 15 industries in Massachusetts. One such company is a printing plate producer that uses concentrated nitric acid in its photoengraving etching process. For years the firm had been disposing of the spent acid in its wastewater discharge after first neutralizing it with sodium hydroxide.

Nowick was asked to investigate whether it was possible for the company to reduce its use of nitric acid and sodium hydroxide, both of which are expensive and potentially hazardous to workers and the environment. Nowick proposed the use of a recently developed acid recycling system that uses diffusion dialysis. Trials in the plant demonstrated that 95 percent of the spent nitric acid could be recovered and purified for reuse.

"Not only was the nitric acid discharge cut significantly," Nowick says, "but the need for sodium hydroxide was drastically reduced. The company was able to realize its goal of producing high-quality etched products while producing as little waste as possible. This strategy not only significantly lowered the risk associated with the storage and handling of hazardous chemicals, but it will have financial benefits by reducing the need to purchase raw materials, as well as lowering operating and waste-disposal costs."

"We have found that many companies do not have the resources to research alternatives like this," Paula Nowick says. "Larger companies have downsized their research and development staffs, and smaller companies, especially in New England, have to focus their energies on surviving in fiercely competitive markets. Given strict environmental regulations and today's economic climate, the environmental consultant has become a vital asset for many industries."

Public conservation efforts can also frequently benefit from the types of services that Nowick Environmental Associates offers. For example, a consortium of 20 high schools in Western Massachusetts needed help in finding the most cost-effective way of disposing of small quantities of the many spent and out-of-date chemicals purchased for use in classroom demonstrations and experiments. Since only licensed hazardous waste disposers are authorized to deal with these potentially dangerous chemicals, each school was looking at costs ranging from $2,000 to $5,000 for disposing of less than a 50-gallon drum of waste.

"First, we compiled a master list of the chemicals from all 20 schools," Nowick says. "Through the industrial contacts I have made over the years, we found companies that could use many of these chemicals in their operations. We even found a roofing contractor to take some excess asphaltic materials from one of the schools."

Currently, Hank and Paula are gearing up to help companies comply with regulations being prepared by the Occupational Safety and Health Administration and the Environmental Protection Agency that will require manufacturing companies to review and improve their operations to ensure the health and safety of employees and neighboring communities.

"Part of the process of complying with these Process Safety Management regulations will require the application of the concepts of total quality management, making sure everyone in the company—from managers on down to line workers—becomes involved in the decision making about processes that employ hazardous materials," Paula says.

While Nowick Environmental Associates is their first joint business venture, Hank and Paula Nowick have been partners since first meeting at WPI in 1958, becoming engaged in Paris in 1961, and marrying in 1963.

"Given strict environmental regulations and today's economic climate, the environmental consultant has become a vital asset for many industries."

"It's fascinating to look back at the changes in environmental awareness that have occurred over that time," Paula says. "It's just as fascinating to think about how much our life together has deepened our appreciation of the loving care that needs to be given to all evolving things—especially relationships. All beautiful things need protection and reverence."

— Michael Dorsey and David Brooks

Nancy Conard Helps Keep the Spirit of Earth Day Alive in the Pacific Rim

Over the past two decades, the annual celebration of Earth Day has lost much of its original excitement and visibility. But in the late 1970s, when Nancy S. Conard '80 was in high school, it was still a new and powerful idea, one that influenced her choice of college and helped shape her career.

When Conard decided she wanted a career that combined her budding concern for the environment with her knack for math and science, she went looking for colleges that would enable her to merge these interests. At the time, WPI was one of the few universities offering an undergraduate degree in environmental engineering. That, plus the WPI Plan, with its project-based approach to education, led her to enroll at WPI in 1976.

What she didn't realize then was how her choice of career and college would help her achieve another of her goals: seeing the world. For the first 20 months after she graduated from WPI, Conard worked in Massachusetts for the U.S. Environmental Protection Agency. But since then she's pursued her career entirely in the Pacific Rim, working in Southeast Asia, for a small Pacific island republic and, most recently, in Hawaii.

Her life in the Pacific region began in 1982 when she left the EPA to join the Peace Corps as an environmental engineer. She was sent to Thailand to work with the provincial government in Roi-Et on water resource projects. She helped plan, design and build small dams, spillways and rain catchment tanks. She also spent a great deal of time in the village of Ban Payamnom Noi helping out with a variety of environmental projects.

When her two-year hitch in the Peace Corps was over, she signed on for a third year and was given the freedom to design her own assignment. She decided to go to Chiang Mai University in northern Thailand, where she worked as a researcher and instructor in the environmental engineering program. Fluent in Thai, she taught courses in environmental engineering and industrial wastewater treatment to Thai students. She also helped conduct water quality surveys in northern Thailand.

"I liked working in Thailand," she says, "and I liked the fact that my work made a clear difference in the lives of people." She realized that to remain in the environmental field she would need an advanced degree. She was accepted by several universities, but chose the Master of Public Health Program at the University of Hawaii.

She attended the university with a prestigious scholarship from the East-West Center for Intercultural and Technical Exchanges. Funded by the U.S. government, the East-West Center has a staff of full-time researchers, fellows and associates and sponsors a cadre of graduate students at the University of Hawaii. Of the 150 to 200 students who conduct research through the center each year, about 25 percent are from the U.S. and the balance come from various Asian and Pacific island nations.

Conard says her work through the East-West Center gave her valuable international professional ties. But the public health program focused more on identifying and managing environmental risks, and less on treating and mitigating them, which were her interests. To learn more about the practical, hands-on side of environmental work, she stayed on to earn a second master's degree in civil engineering in 1987.

With her graduate work complete, she took a job as executive director of the Environmental

Early in her career, Nancy Conard worked as an environmental engineer in Thailand, where the local fauna includes elephants. She has remained in the Pacific Rim since then, running an environmental agency for an island nation and working for several consulting firms in Hawaii.

"I believe it is important to balance environmental and public health concerns with real-world needs, such as housing, economic development and so on. Sustainable development and assessing risks to the environment and human health are both key to 'environmental management.'"

MICHAEL OORSEY

David Ploss, right, and H. Robert Nyce of Ploss Associates. The firm, founded by Ploss in 1985, provides a range of environmental services and also offers an on-line information service that keeps clients up to speed on the latest news on environmental laws and regulations.

Quality Protection Board of the Republic of Palau. Palau was then part of the United Nations Trust Territory of the Pacific Islands and was administered by the U.S. Located about 800 miles southwest of Guam, Palau is made up of some 340 islands in the Caroline chain, many of which are uninhabited. Its 15,000 citizens live in an area roughly twice the size of Washington, D.C.

The Republic of Palau gained its independence last October, the last U.N. Trust Territory in the Pacific to do so. When Convard went to Palau in the late 1980s, the U.S. EPA was working with local officials to help them prepare to manage their own environmental programs after independence came.

Convard says the nation's early environmental program focused primarily on sanitation and rural environmental health. But the newly established Environmental Quality Protection Board was charged with addressing other environmental issues and creating new programs for the country, whose small economy was built primarily on tourism, subsistence agriculture and fishing. The tourist industry is considered to be of great importance to the nation's economic future.

"When I arrived, the board was not very active," she says. "Its staff was implementing the program through other government departments. My role as executive director was to manage the technical staff. I reported to an appointed board that made policy decisions based on the staff's technical analysis and recommendations."

For nearly three years, she helped set the new agency's scope and agenda. She and her staff reviewed the nation's existing environmental regulations, drafted new regulations, and recommended others to meet unaddressed needs. Under her direction, the board became a quasi-independent government agency, no longer under the control of any other department or ministry. She said this helped the board remain objective as it reviewed the nation's development efforts, which were largely directed by the national government.

"The board had pretty much all of the program areas that the U.S. EPA has: water supply, marine water quality, solid waste and hazardous waste, which in Palau primarily meant pesticides, household hazardous waste, petroleum products, and so on," she says.

"Palau is a wonderful place. It has some of the best—if not the best—scuba diving in the world, and it has some terrific people. I had a great time there; it was the part of my career of which I'm most proud. But the time came for the Palauans to take over. Since I left, I've stayed in touch with many of the people I worked with there."

In the spring of 1990, Convard began a new job with PRC Environmental Management Inc., a consulting firm in Honolulu. A year later she was offered the opportunity to open a Honolulu office for EnviroSearch International, a small firm based in Salt Lake City.

"EnviroSearch wanted to do international work and I had contacts in the Pacific region that allowed me to get project work," she says. "I worked on projects for governments and agencies, particularly the American Samoan government and the South Pacific Regional Environment Program, a regional international environmental technical assistance organization with representatives from governments throughout the Pacific region. I also added another continent to my resumé when I was asked to conduct an assessment of hazardous waste management in Botswana."

After two years with EnviroSearch International, she joined Parametrix Inc., a 300-person consulting firm based in Washington state. While Parametrix is known in the mainland U.S. as a multidisciplinary environmental firm, its Honolulu office had focused largely on water/wastewater engineering. Convard was asked to expand the environmental practice in Hawaii and in the Pacific, which she did until late 1994, when the company decided to scale back its Hawaiian operation and focus on the Pacific Northwest.

In November 1994 she joined Barrett Consulting Group Inc., which has a 300-person staff that works in offices in California, Washington, Hawaii and Guam. As senior environmental engi-

"Having the opportunity to tap into needed information with a few keystrokes puts an end to flipping and browsing through mountains of manuals and documents."

neer/project manager in Honolulu, she will continue to work with several clients she brought with her from her previous job and further develop her expertise in areas like toxic waste remediation and solid waste management—in Hawaii and in the international arena. "We're looking at potential projects in the Maldives, Southeast Asia and the Cook Islands, among other areas," she says. "A four-month assignment to develop improved solid-waste management and environmental agency strengthening should be completed by this fall."

Convard says her work as an environmental consultant has been quite varied. Her earlier assignments—including her Major Qualifying Project at WPI—dealt with water quality. The MQP, completed with Betsy Steigerwald Yingling '80 and Grace (Crooker) Levergood '80, was a study of the Muschopauge Reservoir watershed in Rutland, Mass. "That project was actually similar to some of the work I've done as a consultant, where the environmental impacts of development projects are considered in the planning process or management of water resources," she says.

Today, many of her assignments in Hawaii focus on the environmental assessment, environmental audit, investigation and remediation of hazardous waste sites. For the foreseeable future she says she will likely continue this work on an international scale, helping governments balance economic development with adequate environmental controls. For her industrial clients, she sees her work turning more and more to areas like pollution prevention and waste minimization.

She says her work on international environmental projects has been particularly exciting, "because it solves real problems and provides proactive environmental management. I believe it is important to balance environmental and public health concerns with real-world needs, such as housing, economic development and so on. Sustainable development and assessing risks to the environment and human health are both key to 'environmental management.'"

— Diane Benison

Ploss Associates Brings Environmental Services to the Information Highway

When companies need more solid footing as they slog through the quagmire of environmental health and safety regulations, they can log into an on-line service maintained by Ploss Associates, an environmental consulting firm in Northboro, Mass. The service can give them answers around the clock, seven days a week.

F. David Ploss '70, founder and president of Ploss Associates, designed the new service, called Ploss Environmental and Safety Information Service. "We wanted businesses that had been dependent upon trade journals or that found themselves swamped with regulatory data to be able to get the information they need from a central source in a concise form," Ploss says. "Having the opportunity to tap into needed information with a few keystrokes puts an end to flipping and browsing through mountains of manuals and documents."

Agencies such as the U.S Occupational Safety and Health Administration and the Environmental Protection Agency are going on-line, Ploss says, but it still takes companies too much time to wade through all the latest regulations. And smaller companies, which his firm serves, rarely have a full-time regulatory affairs employee to do the work. Ploss says he and his staff glean the information they offer on-line on their own forays into the Internet. "We get the information because we need it in our work with specific clients," he says.

He says he decided to start the unique service about a year ago when he was downloading information from OSHA and realized that his client needed the same information but might not know how to find it. Now he makes the information—including news about proposed legislation—available to clients for a small monthly fee. It can be accessed by modem or through the Internet. So far, more than two dozen companies have signed on.

Michael Alberts, director of corporate safety and security for Cabot Safety Corp. in Sturbridge, Mass., is one of the service's clients. "I find that if there's something hot going on, I can find it," he says. "It cuts right to the chase." Norman Faucher, owner of CAC Industries Inc., says such a service has long been needed. "Before I joined, I was often unable to easily access the latest regulations, so I'd follow the old ones and hope for the best," he says. "I'd sometimes find out later that many were outdated by at least a couple of months."

In addition to access to information, the monthly fee also gives clients on-line support and two hours of free phone consultations each quarter. For a higher fee, companies can set up a bulletin board system for their employees. "For example," Ploss says, "a firm with 10 manufacturing plants around the country might want its own internal memo system so staff managers can discuss the latest EPA and OSHA regulations among themselves. Our service could, if requested, then supply them with the names of key agency persons to contact about regulatory changes."

Although the budding on-line service is presently on the front burner at Ploss Associates, the firm also specializes in providing solutions to environmental, safety, industrial hygiene and regulatory problems at companies—small and large—around the country. It conducts environmental site audits, environmental due-diligence investigations, industrial hygiene sampling and safety audits, and industrial program development, among other services.

"We also develop and assist in the implementation of hazardous waste management programs, audit existing programs and provide required training for clients," Ploss says.

The firm has completed a wide variety of projects since Ploss founded it in 1985. For example, it evaluated how fly ash is handled at the incineration facilities of a large municipality, prepared a corporate safety manual for a large New England

"Liabilities that are not at first apparent in proposed mergers can cost a firm millions of dollars. We can evaluate the potential liabilities before the transaction is completed and can, possibly, prevent a firm from assuming significant financial responsibilities."

corporation, and prepared and implemented a "Worker's Right To Know" program at a small printing company.

Ploss Associates also has experience in making environmental risk assessments prior to business acquisition and mergers. Its clients currently include a leading private investment company in New York and a development company and law firm in New England. "Liabilities that are not at first apparent in proposed mergers can cost a firm millions of dollars," Ploss says. "We can evaluate the potential liabilities before the transaction is completed and can, possibly, prevent a firm from assuming significant financial responsibilities."

Ploss says he relies on networking to build his business. "When you work for yourself, you're your own salesman. You follow up on referrals. You make cold calls. You ask people if they have any problems that you can help solve. We've been fortunate in being able to get ahead on a lot of word-of-mouth and repeat business."

The "we" behind Ploss Associates is a WPI alumni duo. Working with Ploss as a project manager is H. Robert Nyce Jr. '93, who has 16 years of environmental experience, mostly in the construction and consulting field. He has managed air-quality, safety, industrial hygiene and regulatory projects for a number of firms, including an abrasives manufacturer, machine shops, construction businesses, printing facilities, and trash-to-energy plants.

Ploss' own experience includes course work at the Harvard School of Public Health and nearly two decades at Norton Co., where he was corporate administrator of Environmental, Health and Safety Services. He has also worked as a chemical engineer for Factory Insurance Association, a fire protection insurance carrier in Detroit, and for Kemper Insurance Co. in Philadelphia.

He has served on committees to develop industrywide compliance procedures and has been retained as an expert witness in numerous environmental- and safety-related legal cases. An authority on Workers Right To Know legislation and OSHA compliance, he has been a consultant to the Grinding Wheel Institute, the Abrasive Grain Association, the Smaller Business Association of New England, the Risk and Insurance Managers Society, and the Associated Industries of Massachusetts. A registered environmental assessor, he is also certified as a safety professional, hazardous materials manager, environmental inspector and plant engineer.

"When necessary, we add the services of additional certified industrial hygienists and safety professionals, as well as toxicologists, biologists, hydrogeologists, geologists and surveyors," Ploss says. "But most of the time, it's just the two of us." And that's just how he likes it. "You know," he says with a grin, "I really do like being my own boss and calling the shots."

Calling the shots is something that comes naturally to an experienced rower, coxswain and crew coach who once made it to the finals of the Canadian Nationals in the singles event. For more than 13 years, beginning in 1972, Ploss coached the WPI Crew Club, a six-day-a-week job. Under his guidance, the team won numerous titles, including the Four With Coxswain title at the National Championships in 1978, the City of Worcester Championship (for 12 years), and the New England Championships in 1979.

In 1982 he led the first alumni contingent and student crews to row in the Reading Regatta in England (a preliminary race to the famed Henley Regatta), where they won three trophies. Ploss' dedication as rowing coach, along with his work as a class secretary, a class agent, and chairman of the 15th Reunion of his WPI class, won him the 1985 John Boynton Young Alumni Award for service to WPI.

Like rowing, Ploss says he finds that being an entrepreneur has its rewards and its risks. "I'm in control of my career now," he says. "I didn't feel that way when I worked for a big company. On the other hand, I have to think about a lot of other things that I wouldn't have otherwise—like meeting a payroll."

— Ruth Trask

Former Chemical Engineer is a Lawyer for the Land, Water and Sky

In the mid-1980s, Paula (Green) Curry '82 dealt with dirty water. A chemical engineer, she designed industrial wastewater treatment systems to help companies meet clean water requirements. While her clients now had clean water, Curry discovered they didn't really understand the host of other environmental regulations their businesses faced. "They needed legal advice," she says. And the regulations fascinated her. So she decided to become a lawyer.

A native of Auburn, Mass., Curry graduated from Boston College Law School in 1990 and joined the 100-year-old Boston law firm Bingham, Dana & Gould as an associate. A national firm with more than 200 lawyers, Bingham, Dana & Gould offers its clients a full range of legal services. Curry is a member of a small group that offers counsel on environmental issues.

While she practices environmental law, Curry says she operates more as a businessperson. A large part of her work is providing environmental due diligence, she says, by arming businesspeople with the right information—both legal and technical—to make an acquisition decision.

For Curry, environmental issues are "not just for people who live in Cambridge and wear Birkenstock sandals. These are real business issues people have to deal with." On many cases, she reviews technical data on a piece of property, including groundwater and soil tests, and undertakes literature searches on the site and surrounding area.

"My goal is to get the best possible outcome for my clients," she says, "and help them work through all kinds of messes," from owning environmentally hazardous sites on the federal Superfund list, to lending money to companies who bought property discovered to have been a toxic dumping ground a generation ago.

"My goal is to get the best possible outcome for my clients and help them work through all kinds of messes."

"What my clients want to know is, 'What is the likelihood I will have to pay for this?'" Curry says. "I help them evaluate the risk." And the risks can be significant if a $35 million to $40 million transaction is at stake.

As for the potential price tag for cleaning up a hazardous waste site, Curry refers her clients to environmental consultants. "I try not to advise my clients whether or not to buy a property," she says. "The client picks a team and we approach the problems together."

Why should businesses worry about the environment? If they want to buy, sell or build on land, they have no choice—especially if the land is in densely developed New England. Several state and federal laws enacted over the last 20 years have changed the commercial real estate landscape, especially where ground or water contamination is suspected. If tests reveal contamination from hazardous waste, the federal Superfund Act imposes strict liability for cleanup costs on any person who ever owned or operated a business on the site, without regard to fault.

"Basically, the government can go after anybody in the chain of title," Curry explains, and ask them to clean up the mess. Other common statutes businesses wrestle to comply with are the revised federal Clean Air Act, Massachusetts' Chapter 21E (Massachusetts' Superfund statute), and local sewer regulations.

Since Curry first entered the field of environmental law, she says she has seen clients become more sophisticated about environmental laws and regulations. "These statutes have been around 20 years now," says Curry. "People have grown more comfortable with the laws and are more likely to evaluate the risks themselves."

So why switch from chemical engineering? As Curry has explained to WPI student audiences, law and engineering careers have different expectations. Engineering courses, she says, often lead students to solve a problem with one right answer. But law school professors want to see your reasoning, not your answers. Fewer clear-cut solutions may bother engineers, she says, but she doesn't mind working through gray areas.

There are also more women in law, Curry notes, particularly in the first years of practice. "That's one less hurdle to overcome," she says. As an engineer, she often found herself the sole woman on a plant floor and had trouble conveying her competence to her male colleagues. "That made it difficult to do the job," she recalls.

In an environmental law practice, Curry is constantly challenged by a wide variety of tasks. Emergencies arise where she must evaluate material quickly. For example, a company on the verge of signing a deal may suddenly uncover a box of papers with environmental information. Inspectors from the Environmental Protection Agency may appear on a company's doorstep. At any one time, she may juggle eight to 10 different projects.

"You have to be up on a lot of various statutes," she says. "You've got to be a generalist within your specialty."

Curry and her husband, Scott Curry '82, recently acquired a new specialty—parenting. She took a five-month maternity leave last September to welcome their son, Davis, into the world—a world, she hopes, that will be a little cleaner for his generation.

— Allison Chisolm

Paula Curry began her career as a chemical engineer specializing in wastewater treatment. In 1990 she earned a law degree and now is an associate at a Boston law firm, where she counsels clients on environmental issues, including those surrounding the purchase of real estate.

Peter Tunnicliffe Has Built a Career in Environmental Project Construction

When Peter W. Tunnicliffe '74 decided to enroll at WPI, the field of environmental engineering was new, as was the WPI Plan. He says he was willing to gamble on one, but not on both. As a member of one of the early Plan classes, he was free to choose the Plan or WPI's more traditional curriculum. Concerned that the Plan's lack of grades might hamper his ability to get a job, he opted for the traditional route to a degree in civil engineering with an environmental emphasis.

"We're going to see an awful lot of global environmental opportunities as more underdeveloped countries begin to get their water systems up to the current state of the art."

Having worked for a number of years in environmental construction for the firm of Camp Dresser & McKee, Peter Tunnicliffe was named head of a CDM subsidiary, CDM Engineers and Constructors, in 1993. The group specializes in undertaking environmental projects on a design-build basis.

Now president of CDM Engineers and Constructors, a subsidiary of Camp Dresser & McKee Inc., Tunnicliffe says environmental engineering appealed to him because it enabled him to blend his interests in chemistry, the life sciences, engineering and the environment. It also offered good prospects for employment.

At that time, the focus of environmental engineering was water quality and wastewater treatment. Under the Clean Water Act, the federal government was funneling large amounts of construction money into state and local government projects like sewer systems and water treatment plants. There was a growing need for engineers with expertise in design and construction.

Having received his degree in civil engineering, Tunnicliffe decided to take a job with Camp Dresser & McKee, one of several firms that made offers. He says the company's varied portfolio of environmental projects appealed to him. "Some of the other offers would have pigeonholed me," he says. "One company wanted me to be an ion exchange specialist. That seemed too limiting."

Starting in Camp Dresser's construction group, Tunnicliffe worked on a wide range of construction projects, including water treatment plants, wastewater plants, transmission mains, and sewer lines. "I learned an awful lot about construction very quickly," he says, "faster, in fact, than I could have in many alternate career paths. That exposure shaped the rest of my career."

In 1979 he was assigned to the company's New York City office, where he worked on some heavy construction projects designed by a firm acquired by Camp Dresser. "They had a lot of problems," he says. "I rolled up my sleeves, began to resolve them, and ended up relocating to New York and taking over the heavy construction group."

While in New York, he earned a law degree at Brooklyn Law School, something he felt would be an asset in his work in construction management. In 1981 he was named head of the reorganized New York office, which was working on major design jobs, including projects for wastewater plants and landfills. Over the next several years, as Camp Dresser became an important consultant and contractor in the field of hazardous waste, Tunnicliffe began managing projects in that area, as well, including work for the U.S. Environmental Protection Agency and industrial clients.

In 1991, as part of a companywide reorganization, Camp Dresser established several practice-oriented groups focused on national market trends. In 1993, one of those, created to meet a growing interest of industrial and municipal clients in design-build projects in the environmental field, became CDM Engineers and Constructors.

Traditionally, clients have contracted separately with designers and builders to get environmental projects constructed. But with design-build, an approach now common in Europe, a single contractor is responsible for the entire project, which can often save money. Tunnicliffe says he believes this design-build concept will become prevalent throughout the environmental field.

CDM Engineers and Constructors' 14-member staff consists largely of construction project managers and superintendents. For specific projects, the subsidiary works with professionals from other Camp Dresser units, particularly people with design or construction experience.

"Our mission contemplates further growth in the areas of responsibility assigned to our project managers and superintendents," Tunnicliffe says. "It doesn't contemplate growing a series of redundant services that would compete with the parent. One of the core philosophies of Camp Dresser is to function as one team throughout all the operating units. We're not set up to compete among ourselves. That's different than many firms that are set up on a localized profit-center basis. Our goals are structured to promote teamwork between units."

Tunnicliffe says he is optimistic about the future of environmental engineering. In particular, he says the international market will provide a great deal of work for firms like his. "We're going to see an awful lot of global environmental

"Business and industry are learning through experience that pollution prevention and the safe disposal of hazardous waste reduce the exposure of workers to toxic materials and help them stay healthy."

opportunities as more underdeveloped countries begin to get their water systems up to the current state of the art," he says.

"This is happening now on the Pacific Rim. Water system upgrades will be followed by wastewater treatment and, ultimately, by solid waste- and hazardous waste-related work. There are tremendous water treatment and wastewater needs in Eastern Europe because of uncontrolled industrialization. Drinking water is in trouble there and basic wastewater needs are not being met well. All around the world, there are tremendous environmental needs that will have to be addressed in the next decade or two."

— Diane Benison

Still an Activist at Heart, Forcella Helps Connecticut Manage Hazardous Waste

The development of hazardous waste sites is controversial and unpopular, and even more so for low-level radioactive waste-disposal facilities," says Domenic Forcella '70. "But in this initiative, the community, not some outside agency, makes the decision as to whether or not it will participate in the selection of a local site."

Forcella is chairman and executive officer of the Connecticut Hazardous Waste Management Service (CHWMS) in Hartford, an independent, quasi-public agency created by the Connecticut Legislature in 1983 to promote the responsible management of hazardous waste to help safeguard the state's air, water and land. It also helps business operate more efficiently by providing technical assistance in pollution prevention.

In 1987 the agency's scope was broadened to include low-level radioactive waste. Through an innovative voluntary siting program, CHWMS hopes a community will volunteer to host a facility for the management of the low-level radioactive waste generated in the state. He says the new approach gives more control and bigger incentives to a community to establish a site than traditional state siting programs.

Under the program, local governments make the decision to begin discussions about hosting a facility. "It is not imposed on them as has traditionally been done," Forcella says. The community can design criteria for the site to meet its needs, and with the state it develops a "facility development agreement" that spells out the responsibilities of each party and carries the weight of contract law. For its participation, and to offset its costs, the community receives financial compensation from the state that it can use in any way it sees fit. Other states are studying the program, Forcella says.

The activities of CHWMS and its 20 employees are guided by a 10-member board of directors. Its members include Gerald R. Backlund '55, manager of regulatory affairs at the Stamford (Conn.) Research Laboratories of Cytec Industries Inc. Another WPI graduate, Joseph M. Amarello '82, is assistant manager for policy and regulation for CHWMS.

Forcella says that one of CHMWS's most important current missions is promoting waste minimization and pollution prevention among the state's industries. Through the Connecticut Technical Assistance Program (ConnTAP), it provides companies that wish to reduce their waste output with financial and technical assistance.

Attitudes about pollution prevention have changed over the last few years, Forcella says. Once thought of merely as "the right thing to do, environmentally," today it is seen as a more economical and efficient way to manage a manufacturing operation. "Business and industry are also learning through experience that pollution prevention and the safe disposal of hazardous waste reduce the exposure of workers to toxic materials and help them stay healthy," he says. "A healthy work force can mean increased production and profits."

Forcella says managing Connecticut's waste disposal problems is becoming more difficult all the time as other states attempt to close their borders to out-of-state waste. The lack of adequate disposal sites for waste leaves Connecticut facing the potential for the loss of industry and jobs and increases the potential for irresponsible disposal and illegal dumping, he says.

All this makes the need for in-state waste disposal solutions more critical, although no less complex or controversial, he says. "While simple solutions are desirable, they are increasingly more unlikely. Solutions to the technical and environmental problems of waste disposal are within reach, but they will not come without some expense, and there will be complex political and social hurdles to surmount."

Forcella's interest in public service began when he was a student at WPI. He was instrumental in setting up a program called the Worcester Area Free University, which was open to anyone without age restrictions or residence requirements. "Our goal was to bring people from institutions of higher learning together with people from the community at large who were seeking solutions to problems," he says. "We placed more emphasis on practice than on theory."

He also became interested in environmental issues as a student, serving on the Worcester Chamber of Commerce's Beautification Council and Environmental Committee and helping organize the Institute's observance of the first Earth Day in 1970. After receiving his degree in civil engineering and starting a job in the Worcester City Planning Department, he began his graduate work in civil engineering and environmental planning at WPI and founded the Worcester Ecology Action Center, which used radio shows, political lobbying, speakers and advisors in its efforts to improve Worcester's environment.

In 1974 he interrupted his graduate work to become the first chairperson of the Inland Wetlands Commission in his hometown of Plainville, Conn. During the next several years he worked at a variety of jobs, including substitute teacher in the Plainville schools, instructor at

"Solutions to the technical and environmental problems of waste disposal are within reach, but they will not come without some expense, and there will be complex political and social hurdles to surmount."

Briarwood College in Southington, Conn., justice of the peace, photographer, feature writer for the *Plainville News,* and consultant for an environmental studies program at Central Connecticut State College in New Britain.

Long active in Connecticut politics (he is a past chairman of the Plainville Democratic Town Committee and a former vice president of the state's Young Democrats), he was nominated in 1978 to run (unsuccessfully, as it turned out) as the Democratic Party choice for the 22nd State Assembly District, which includes Plainville. He also worked on the political campaigns of his father, a former mayor of Plainville, and former WPI professor Carl H. Koontz, who served as a city councilor in Worcester.

"I started my first important post in 1979," he says, "when I was appointed by Connecticut Governor Ella Grasso as executive director of the Connecticut Council on Environmental Quality." For five years he served as an ombudsman for the state, overseeing environmental issues and legislation and addressing citizens' problems. Under his direction, the council became involved in such potentially thorny issues as hazardous waste siting, drinking water contamination and solid-waste disposal. It also investigated the impact of the construction of large shopping malls on the environment.

In 1983 he received a Mellon Fellowship for Academic Research and enrolled at Yale University's School of Forestry and Environmental Studies to complete work on a master's degree in environmental policy. Three years later he stepped down from his executive director's post to pursue a Ph.D. in environmental design and planning at Virginia Polytechnic Institute and State University under a Cunningham Fellowship for Dissertation Research.

"Dom's work with the Council on Environmental Quality has emphasized citizen concerns, and his efforts to solve problems that were varied and complicated have made us that much more effective," attorney Donald Mackie, then chairman of the council, said at the time. "His concern let the public know that the council is a unique government agency that has a mandate to follow through on citizen complaints."

At Virginia Polytechnic, Forcella conducted research on facility siting procedures, small-quantity waste generators, household hazardous waste, and emergency response. He prepared reports on hazardous waste issues for local officials in Virginia cities and towns. For two years he was a facility siting consultant to the National League of Cities.

In 1987 he was named a senior policy analyst for the Natural Resources Center of the National Governors' Association. In that post he directed a pollution prevention study, staffed the Governors' Task Force on Solid Waste, coordinated a Superfund policy forum, directed work for the Waste Capacity Assurance Project, and assisted in a survey of areas closed or restricted due to toxic contamination. This work required close collaboration with state environmental staffs, the EPA, industry representatives, and environmental groups.

Over the years, Forcella's know-how and creative approach to problem solving have made him a much-sought-after committee member and speaker. Among the many committees on which he serves are the U.S. Environmental Protection Agency/NGA Environmental Justice Work Group, the State and Territorial Solid Waste Management Officials Pollution Prevention Task Force, and the U.S. Department of Energy's Federal Facilities Compliance Act Task Force.

He has written extensively about environmental issues and has presented the results of the work of CHWMS at national conferences and to work groups at the National Governors' Association. He is listed in *Who's Who in American Politics* and *Who's Who in Pollution Prevention.*

Forcella was appointed to his current post at CHWMS in 1992 by Governor Lowell R. Weicker Jr. In this highly visible job he says he draws on the varied experience he has gained over the years. Particularly useful, he says, is the political sensibility he began building more than 20 years ago while an undergraduate at WPI.

Active in a campus protest of the U.S. military invasion of Cambodia, he earlier had found himself, as a member of the Student Activities Board, voting against a motion to spend student government money to rent a bus to carry students to Washington, D.C., for a moratorium in late 1969. He says he opposed using general student funds to support the political views of one segment of the student body, "even though I may have agreed with those views.

"From that experience I learned the value of compromise," he says. "You have to push as far as you can for yourself, but you can't be inflexible. You need to work hard to get things done, especially in the environmental arena where so many people hold diverse views. Sometimes, such as with our voluntary community siting program, we win one."

— Ruth Trask

Monsanto Engineer Has a Message for Today's Students: Environmental Engineering Pays

Edward Jamro '73 learned early on the value of environmentalism. He grew up in Central Falls, R.I., in the 1950s, long before recycling was fashionable. When his mother made Ed and his brothers bundle rags and newspapers and cart them to the junk dealer, he found out that there was money in conservation—often enough for a movie or a hot fudge sundae.

Now, as manager of environmental protection for Monsanto Co.'s Indian Orchard Plant in Springfield, Mass., he is in a good position to get that same message out to today's young people. Environmental engineering pays, he says, and not just for those who work in the discipline, but for companies and communities.

"Never lose sight of the fact that this really applies. Every time you help a worker do his or her job better, you are also helping the environment."

Jamro loves to talk about his work and to promote the field of environmental engineering to students at WPI, where he earned a bachelor's degree in chemistry, and at the University of Massachusetts, Amherst, where he earned a master's degree in environmental engineering in 1975. "In the late '60s and early '70s, when I got interested in this field, we had red rivers, white rivers, green rivers—rivers catching on fire," he says. "I know Institute Pond near campus isn't a good place to swim, but you should have seen it when I was a student."

The first Earth Day in 1970 had Jamro, then a freshman, on his hands and knees, picking up litter in Institute Park with some of his Sigma Alpha Epsilon fraternity brothers. As a junior, he got his feet wet in the environmental field by monitoring carbon monoxide levels in the streets of Worcester through WPI's Environmental Systems Study Program, a precursor of today's student projects. He says this work gave him credentials to break into his chosen career.

Jamro has spent the past 20 years working to minimize Monsanto's negative impact on rivers, groundwater, air quality and the environment in general. Since 1988 he has been responsible for compliance with federal, state and local regulations at the company's Indian Orchard Plant, the largest chemical plant in the state of Massachusetts, which produces resins and plastics. He played a leading role in the plant's voluntary waste-reduction effort, which halved total waste generation and cut toxic air emissions by 89.8 percent between 1987 and 1993. Two MQPs by WPI students have helped to further reduce waste generation at Monsanto; a third project is planned for 1995.

Jamro's professional accomplishments and his dedicated volunteer activism earned him a 1991 Environmental Award from the Springfield Conservation Commission and the 1994 Environmental Excellence Award from the National Association for Environmental Management. In his spare time, he mobilizes volunteer forces in the Greater Springfield community and among Monsanto employees. He helps organize Springfield's annual Earth Day Fair, and he helped found the nonprofit Local Emergency Planning Corporation to raise funds for local emergency needs.

Jamro has been recognized locally for starting a citizens' project to monitor water quality on the Chicopee River, and for sustaining a similar project on the Mill River, both in Western Massachusetts. On Saturday mornings he can be found with his 18-year-old son, Terry, dipping sample jars into the tea-colored water to assess dissolved oxygen levels, biochemical oxygen demand, phosphates, organic and total carbon levels, fecal coliform counts, and pH.

He predicts that the job of the environmental engineer will get tougher and tougher, as stronger environmental protection standards are passed and as the drama of burning rivers and pea-green lakes passes from the public consciousness. He acknowledges that the first steps in addressing an environmental problem are often the easiest; it's eliminating the last bits of pollutants that demands the most of an environmental engineer. That, he notes, accounts for the current focus on "source reduction," which seeks more efficient manufacturing processes that reduce the need for hazardous reactants and avoid the creation of toxic by-products in the first place.

The environmental engineer's most important charge, he stresses, is to make sure that environmental awareness trickles down. "If it's 3 a.m. and a scrubber stops working, what can you do?" he asks. "The operator has to have the motivation and the know-how to get it working or halt production."

He points to a diagram of the water cycle as he addresses a group of students at a recent WPI lecture. "Never lose sight of the fact that this really applies," he tells them. "Every time you help a worker do his or her job better, you are also helping the environment."

Jamro reminds skeptics that what was acceptable for industry just a generation ago is unthink-

Domenic Forcella, right, and Joseph Amarello '82 watch a videotape produced by the Connecticut Hazardous Waste Management Service for local communities. The agency, headed by Forcella, runs an innovative voluntary siting program for hazardous waste facilities in the state.

Edward Jamro with an Earth Day display about emergency planning and response projects in Springfield, Mass., in 1992. Jamro, who is manager of environmental protection for Monsanto's Springfield, Mass., plant, is also active in environmental organizations in the area.

"A site may look like a deli or a hairdressing salon today, but you might find underground storage tanks that were paved over, or floor drains from a prior occupant that leaked industrial solvents or oils."

able today. As an example, he cites an environmental impact study from the 1960s that, in essence, concluded, "'Discharge into this river is OK because the river is so polluted already, it won't know the difference.' You weren't brought up the way we were," Jamro tells today's students, who will be tomorrow's environmental engineers. "I think we need one more generation of dedicated environmentalists to really make things change."

— Joan Killough-Miller

Getting Environmental Information to the People Is the Goal of Lisa and Geoff Wadge

If you were thinking about buying a $5,000 used car, you might have a mechanic look it over to make sure you weren't about to get stuck with a lemon. If you were about to sink $1 million into a piece of commercial real estate, you might want to hire a different kind of expert to save you from jumping into the purchase of an environmental nightmare—a sort of "environmental detective" who could dig up any dirt on the site's past, run background checks on its previous uses, and cross-reference the findings with data from local, state and federal agencies.

That's precisely what Lisa (Katz) Wadge '82 and Geoff Wadge '81 do. They are a husband-and-wife team of private environmental investigators with the scientific and legal know-how to evaluate the potential liabilities of any type of real estate—residential, commercial or industrial. Their clients may be prospective buyers or sellers and include businesses, hospitals and universities, as well as banks and investors. Their services are vital to those who need to know exactly what they're getting into before embarking on a real estate transaction.

The Wadges, who met at WPI and were married on the lawn of Higgins House in 1982, have launched two successful businesses that work together to offer clients peace of mind. EnviroAudit Ltd., founded in 1988, is an environmental consulting firm that performs customized site assessments. These may range from looking up records at the local town hall, to testing soil and groundwater samples for contaminants, to locating and removing underground oil-storage tanks. "Our market niche is clearly the investigative side, as opposed to the cleanup and remediation sides," says Geoff.

The need for such services comes from recent "transfer trigger laws," such as Connecticut's 1985 Transfer and Superlien Act. "It's a kind of lemon law for real estate transactions," Lisa says. "If the seller doesn't disclose certain conditions, the new owner has the right to seek recompense from the previous owner.

"The intent is to encourage parties who are coming together in a purchase-and-sale environment to 'fess up' about environmental conditions. The transfer trigger regulations have encouraged all people to understand and clean up even the smallest environmental liabilities. Under the context of these provisions, we're able to short-circuit and resolve issues that the government has been unable to manage for years."

To date, 11 states have enacted similar regulations, including chapter 21E in Massachusetts and ECRA in New Jersey. The findings in some cases suggest that purchasers must show that they have performed "due diligence" and made "all appropriate inquiry" to determine if environmental factors might impact the value of the property or human health.

"EnviroAudit *is* due diligence," says Lisa. "If you can show that you made the proper inquiries, you may have the right to go back after the prior owner, should something new come up." The company offers customized services packages, with fees ranging from $300 for a simple database search, to $10,000 and up for soil and groundwater sampling using a large drilling rig. Although clients sometimes grumble at the initial

BILL BURKHART

Lisa and Geoff Wadge look over site plans in the offices of EnviroAudit Ltd. and EnviroCheck Ltd., which they founded in Connecticut. EnviroAudit specializes in due diligence work, while EnviroCheck is a computerized resource that provides clients with copies of government records.

"We believe that environmental information belongs to the people. The more people understand about what's happening in their community, the more real action we'll see in managing environmental issues."

expense, the value of the information can be priceless.

"A site may look like a deli or a hairdressing salon today," Lisa cautions, "but you might find underground storage tanks that were paved over, or floor drains from a prior occupant that leaked industrial solvents or oils." Other common findings include the presence of lead-based paint, asbestos or radon, as well as soil and groundwater contamination resulting from ancient septic systems.

"Not all problems spell total disaster," says Geoff. "The solution could be as simple as removing a leaking tank and some contaminated soil. On the other hand, a groundwater pollution problem that requires pumping and treating can cost hundreds of thousands of dollars to clean up." Armed with this kind of information, a buyer can outline cleanup actions and negotiate costs with the seller—before it's too late.

EnviroAudit grew out of Lisa's previous work in groundwater investigations for a small civil engineering firm. With her employer's encouragement, she struck out on her own, working out of a small room in the couple's Killingworth, Conn., home. Geoff was working as a mechanical engineer for Union Carbide Corp. at the time, a job he'd taken after graduating from WPI.

After seven months, EnviroAudit sales grew to the point where "things were too crazy around the house," he says. Geoff quit his job and the Wadges rented an office and hired their first two employees. Their dream of meeting a sales quota of $30,000 in the first year was surpassed with a whopping $90,000 worth of business.

In the course of running a consulting business with current annual sales of $700,000 to $1 million, the Wadges found that obtaining government records was a constant obstacle. "We started to copy the records and keep them in our office...never realizing what we were starting," recalls Lisa. "Six years and a half-million pages later, we created a database that grew into a second company."

EnviroCheck Ltd. is a computerized information library that provides access to a database with hard copies of government records. Using a newly programmed search routine created under Geoff's guidance, the Wadges can type in the name and address of any location in New England and search for relevant environmental data. They can provide clients with hard copies of environmental regulations, historical documents and lists of hazardous waste sites.

How important is this type of information? Lisa relates the story of a state historical society that was planning an archaeological dig. "They put a Styrofoam cup into the water to get a sample, and the cup dissolved. We called the location up on the computer and found out they were working on a heavily contaminated Superfund site and didn't know it. We're trying to get data out to people who might not be aware that this type of information is important to them."

Tracking down information can consume more time and effort than many clients can spare. Environmental records are typically separated by environmental media (air, water, solid waste) and can be stored at numerous locations. Some government offices are only open a limited number of hours each week. Although one is often required to make an appointment in advance and wait on line, there's no guarantee of locating the needed information before closing time. The records may be misfiled, missing or filed under a previous owner. With their computerized search facility and in-house records, EnviroCheck can find information faster and more cost-effectively than a manual search though bulging file cabinets at state and local offices.

Clients of EnviroCheck might include a homeowner, the local dry cleaner, a *Fortune* 500 company, local planning and zoning authorities, or lawyers and engineers representing any of the above. One of EnviroCheck's best customers is EnviroAudit, which consults the database for advice every day.

In December 1994, the Wadges sold EnviroAudit to a large New England utility company and retained ownership of EnviroCheck. Lisa remains as president of EnviroAudit and works one day a week for EnviroCheck; Geoff now works full time for EnviroCheck. Lisa describes herself as the "outside person," doing the marketing, obtaining records and responding to legal issues. Geoff is the "inside man," managing EnviroCheck. Until the recent transfer, he managed field activities, such as drilling and sampling, as vice president of EnviroAudit.

The Wadges say they enjoy their business partnership. "A lot of people shy away from working with their spouses," says Lisa, "but I think engineers are well-suited to work together, because we are pragmatic and problem-solving. We've had our tense moments, but I wouldn't trade working with Geoff for anything in the world." The flexibility of working together allows them to share in the care of 2 1/2-year-old son, Justin, as well. Both companies are located close to their home, in the scenic Connecticut River valley community of Centerbrook.

The uniqueness of EnviroCheck, and the wealth of the information the Wadges have acquired, offer exciting possibilities, such as linking up with on-line computer services, or plotting the data by location, so that it can be searched and displayed in map form, rather than by typing in words. They intend to maintain their database in Connecticut, Rhode Island and Massachusetts, while expanding into Maine, New Hampshire and Vermont.

"There are other private companies that broker federal data, but there's no one else in New England that has what we have," Lisa says. "There's no one else crazy enough to do what we did! It's very time-consuming. Everything that we have is available to the public (under the federal Freedom of Information Act), but it's more cost-effective for clients to get it through us.

"We believe that environmental information belongs to the people. The more people understand about what's happening in their community, the more real action we'll see in managing environmental issues."

— Joan Killough-Miller

The Search for Everett Leach

By Joan Killough-Miller

In the summer of 1945, a twin-engine plane fell from the sky and crashed at the edge of a cornfield on the Isle of Wight. The pilot, a young American major in the Army Air Force, was killed instantly. From the next field, a farmer watched in horror as the plane caught fire and exploded.

The news was relayed to the pilot's family. His civilian boss, Luther Martin '25, sent word to Alumni Secretary Herbert Taylor, who reported the death in the *WPI Journal*. "EVERETT W. LEACH, '38: Fourth graduate of the class to lose his life during the war, Ev Leach was its acknowledged leader. He was elected permanent class president after having served in that capacity during the senior year. He was also president of Skull...."

Leach was only one of many alumni of the 1930s and 1940s reported dead, missing or wounded during the war. In those days, the *Journal* devoted as many pages to a column called "From the War Theaters" as it did to "Around Boynton Hill." In 1950, Leach's photo appeared again in the *Journal*, when he was awarded a posthumous Distinguished Flying Cross.

His wife, the former Idella Muir, remarried and moved to the West Coast. Another classmate took on his duties as class president and agent. His alumni file was closed, and eventually came to rest in the archives in Gordon Library.

But one person could not forget Everett Leach. Nils Askman, who trained with Leach at Standard Oil (later ESSO, and now Exxon), was filled with questions about his friend's death. Where, exactly, did his plane go down? Why was he flying the training plane over the English Channel that day? What happened to his remains?

Askman and Leach became fast friends when they met in Standard Oil's student engineers training course and were later assigned to work in the same division. Both men enlisted in 1941. The Army split them up for training, but they were happily reunited at Turner Field in Georgia. In an amazing series of coincidences, Askman and Leach found themselves posted to the same locations over and over again through most of the war.

In 1945 Leach was sent to England to work on a jet engine for a newly developed fighter plane. Askman was awaiting overseas assignment, but got only as far as Long Island, N.Y., when the war ended. He was there when he got the call from Della Leach informing him of his best friend's death.

Askman's career with ESSO took him to Europe and Asia, including several assignments in England. It was there that he met his wife, Daphne, a nurse from New Forest, not far from the Isle of Wight. While living in England, the couple investigated Leach's death, but uncovered very little, since most information was still classified. After retirement in 1978, they returned to Askman's hometown of Beverly, Mass., and had more time to devote to their search. Time had soothed the grief, and the transcontinental research project became a hobby.

"It's been rather fun, really," says Daphne Askman of their long-distance detective work. A major breakthrough occurred several years ago, when the Askmans tracked down Leach's grave in Worcester. Through correspondence with the RAF's Ministry of Defence, they learned that Leach had been buried in a small cemetery outside of London, but that the remains of all Americans buried there had been moved in 1948, some to the United States.

One person could not forget Everett Leach. Nils Askman...was filled with questions about his friend's death.

A fire had destroyed the relevant records, but on a hunch Askman wrote to the Worcester Department of Parks, Recreation and Cemeteries and struck gold. In 1993 he and Daphne received a map of the plot in Hope Cemetery and were able to pay their respects to Everett Leach.

It was the brother of an English friend who finally led them to the site of the plane crash. When Daphne's mother died, she inherited a cottage near her childhood home. Neighbors David and Mary Hall took Nils and Daphne on a tour of the Isle of Wight, led by Mary's brother, Canon John

Bean, the retired pastor of a church on the island.

After lunch, the Canon drove them to Newport, Isle of Wight's capital city. Without explanation, he dispatched the ladies to a tea shop and led Askman across the street into the offices of the Isle of Wight *County Press*. They searched microfilm of the newspaper starting from July 1945. It wasn't long before Askman reeled to a brief report of the accident.

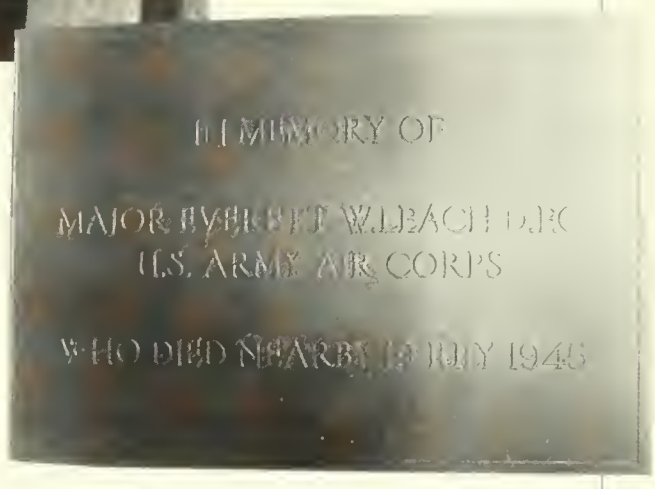
A one-inch story gave the time, date and street location of the crash. Of some consolation was the final sentence: "The Ryde ambulance and the N.F.S. were promptly on the scene, but the pilot was beyond all human aid and must have died instantly."

With those questions answered, a new one arose. How to commemorate the big, good-looking guy, who didn't seem to have an enemy in the world? On a subsequent visit, Bean took Askman to Havenstreet Shrine, a monument erected in 1917 by a farmer who lost his son in World War I. Over time it had become a memorial to all the local war dead, including those lost in battle over the Falkland Islands near Argentina in 1982.

After viewing the shrine, relentless Askman stopped at a dairy farm across the street to ask if anyone remembered the plane crash. The farmer had been a baby during the war, but he directed the couple to 94-year-old Fred Aylett, a former owner. It was Aylett who had stood in his cornfield 50 years ago and watched Everett Leach's plane plummet and burn.

Aylett's eyewitness account confirms the RAF's report of the crash: Leach took off from Boscombe Down at 1130 hours to conduct stability trials on the Airspeed Oxford NM247 at an altitude of 5,000 feet. Askman remembers that Leach was always looking for something to do, and what he loved most was to take up planes with a "red-cross condition" (having just been repaired) to check them out. "He always had his nose in flying—and the mechanics of it, the engineering, and the technology behind it."

Isle of Wight *County Press* Used by Permission



Above, Askman, left, and Canon Bean at the Havenstreet Shrine; right, the memorial to Leach.

Aylett had seen the plane flying over the area for a while before it suddenly started to act up. "He said Ev just fought it all the way down," Askman relates. "And the fact wasn't lost on him either, that Ev was up around 5,000 feet and could easily have bailed out...but he stayed with the plane." The young, life-loving engineer, with a wife and a promising career waiting for him back home, stayed with his plane and steered for the edge of the field, thus sparing the residents of the farm and village the fireball that took his life.

Askman says that while finding the clipping in the *County Press* morgue brought tears, it also brought peace. "When I went to that newspaper office and I ran across that thing on the screen...it was just like when I heard it back in '45, when Della called me," he says. "Now, the sadness of his death has pretty much healed, and the memories of his life are always pleasant."

Why did he search all these years? Like Don Quixote's loyal sidekick, Sancho Panza, Askman has a simple answer: "I liked him." Daphne elaborates: "My husband, being a hard-headed Swede, does not make many friends. And when he does, they really count."

Last fall, the Askmans visited WPI for the first time. They toured Ev's campus and shared their memories and the scrapbook of their quest. Leach's alumni folder was unearthed from the archives in Gordon Library so they could page through photographs, news clippings, and letters in his familiar handwriting.

Although Everett Leach was a WPI alumnus for only seven years, the fragile pages reveal a dedicated Tech man, who signed his class newsletters, "Your Humble Servant."

The wartime correspondence was posted from different bases, but Leach doggedly filed his class fund-drive reports. In one appeal, he chides his classmates for neglecting their alma mater: "Hell, man, I'm busy too. Seven days a week and flying from four to twelve hours a day, and these letters take everyone's time. Please give us a break, will you?"

It's been 50 years since Nils Askman lost his friend. He's found his grail and paid homage, with a bronze plaque dedicated to Leach's memory that was mounted at the Havenstreet Shrine in 1993. Canon Bean conducted a dedication ceremony with three prayers of friendship. Askman is at peace. "When a close friend or relative dies suddenly, you feel like you never had a chance to say good-bye. I figured this was kind of like saying good-bye to him."

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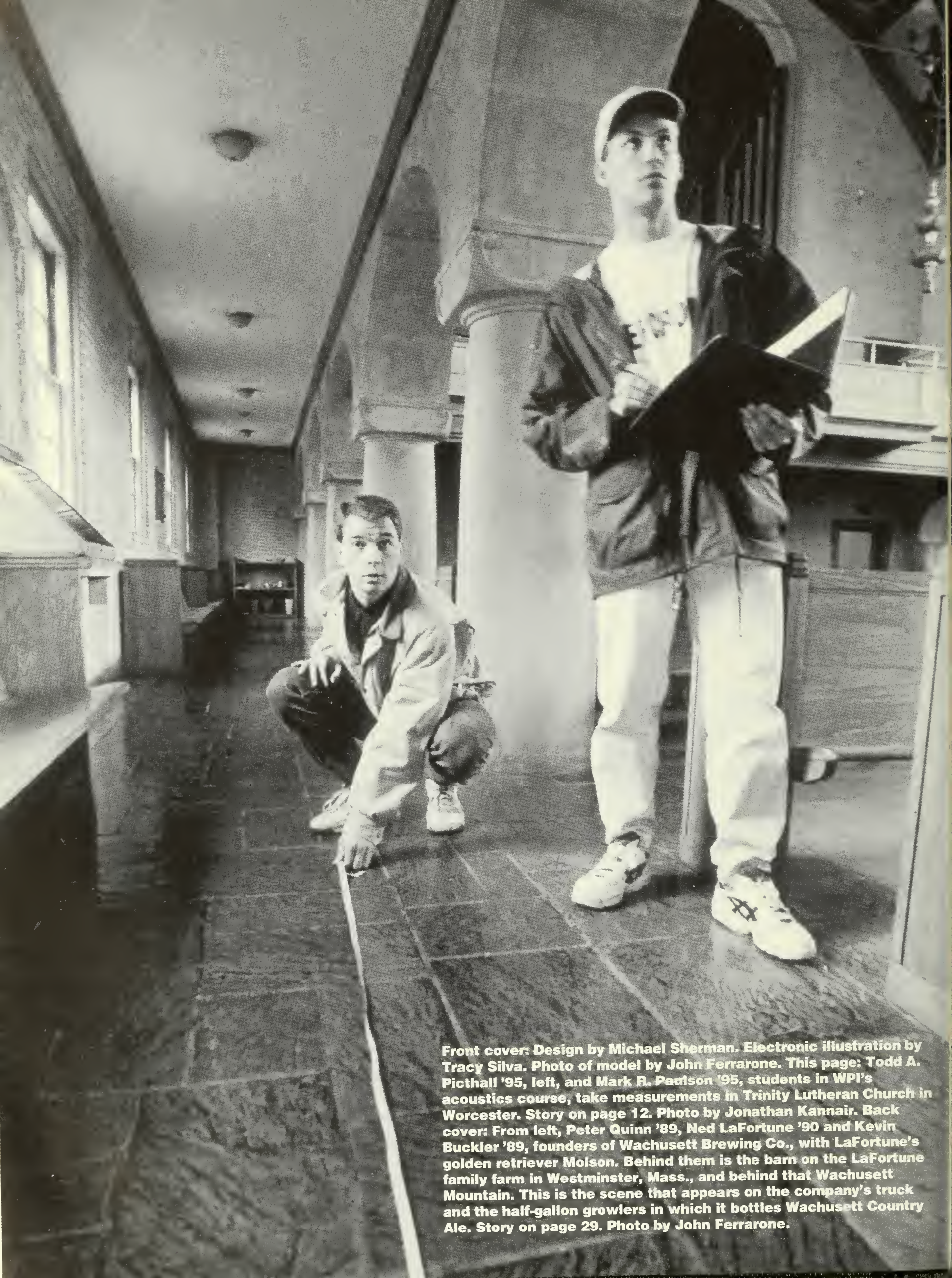
Riding the Waves

- Surviving the Quake in Kobe
- Putting Light Through Its Paces
- Listening to Sounds and Silence



Front cover: Design by Michael Sherman. Electronic illustration by Tracy Silva. Photo of model by John Ferrarone. This page: Todd A. Picthall '95, left, and Mark R. Paulson '95, students in WPI's acoustics course, take measurements in Trinity Lutheran Church in Worcester. Story on page 12. Photo by Jonathan Kannair. Back cover: From left, Peter Quinn '89, Ned LaFortune '90 and Kevin Buckler '89, founders of Wachusett Brewing Co., with LaFortune's golden retriever Molson. Behind them is the barn on the LaFortune family farm in Westminster, Mass., and behind that Wachusett Mountain. This is the scene that appears on the company's truck and the half-gallon growlers in which it bottles Wachusett Country Ale. Story on page 29. Photo by John Ferrarone.

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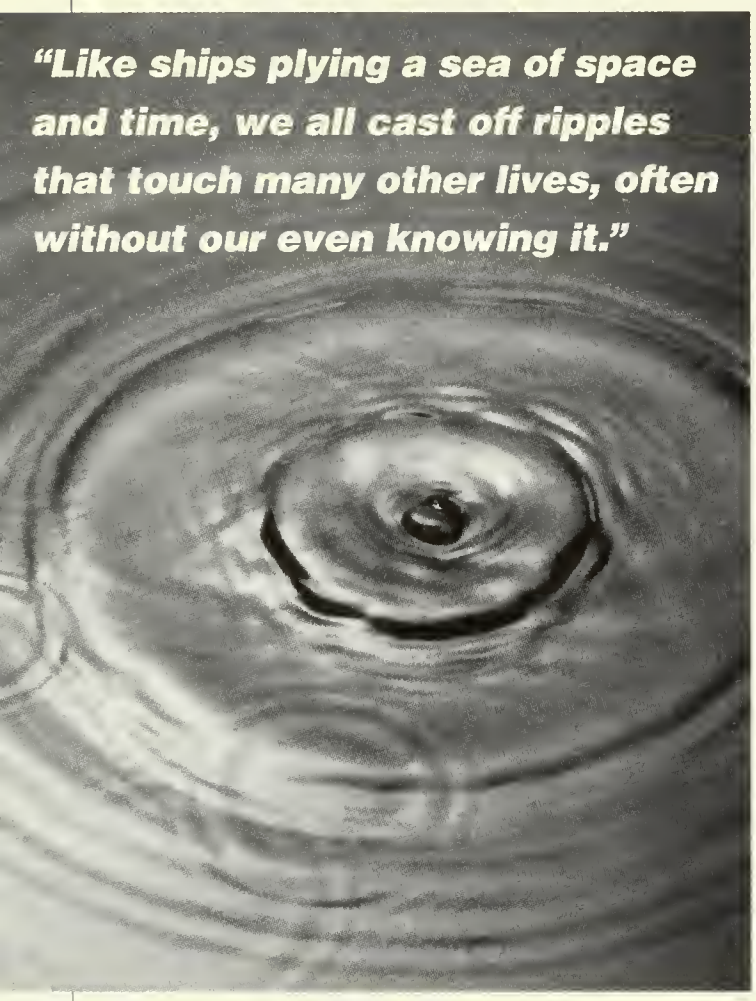
The Power of Waves

By Michael Dorsey



In this issue, we present readers with three very different takes on the idea of waves. In "Blowing Away Goose Tatum" (page 8) we witness the almost unimaginable destruction wrought by the brutal pounding of seismic waves on the city of Kobe, Japan. In "The Light Fantastic" (page 10) we explore the strange and beautiful dances light waves can be made to perform. And in "Good Vibrations" (page 12) we look back on the WPI Acoustics Laboratory's five decades of work with sound waves.

The concept of the wave is a powerful one. Periodic motion is at the heart of many natural phenomena, from the transmission of light and sound, to the tugging of gravity, to the movement of the planets, to the beat of our pulse, to the interactions of the infinitesimal particles that compose all matter. Waves are primal symbols in philosophy, religion, literature and art, standing in for the cyclic nature of life or for the upwelling of new ideas and new technologies that change the course of history.

The wave can also be a powerful metaphor for human interactions. Like ships plying a sea of space and time, we all cast off ripples that touch many other lives, often without our even knowing it. Certainly, Everett Leach '38 could not have fully understood how powerfully the wake of his young life would change the lives of those who knew him.

In the Winter 1995 *WPI Journal,* Joan Killough-Miller wrote about Leach, the young airman who died in a crash of a twin-engine plane on the Isle of Wight in the summer of 1945 ("The Search for Everett Leach"). Leach clearly made an impression on Nils Askman, who trained with Leach at Standard Oil and then repeatedly found himself assigned to the same bases with his friend after both enlisted in the Army. After Leach's death, Askman was filled with questions. He spent more than 50 years tracking down the story of Leach's last moments.

Since that story was published, the *Journal* has heard from several of Leach's classmates and friends, who not only remembered the young and energetic class president, but who were immeasurably enriched by their brief association with him. You will find a letter from one of those alumni on page 6. Another letter arrived just as this issue was going to press. It was from John Rushton '39, who also began his career at Standard Oil and who retired to Oregon in 1993 after working for many years in the lumber and forest products industry.

The story about Leach "hit me right in the gut," Rushton wrote. Leach and Rushton did not become friends until after both had graduated from WPI. When Rushton took a job at Standard Oil's Bayview Refinery in Elizabeth, N.J., Leach took him under his wing. "In fact, I found out after a while that he was the one who recommended me to the fellow who had interviewed me at WPI," Rushton says. "I didn't find that out from Ev, but from the group leader. I owe Ev a lot just for that."

Rushton visited Leach often. "I became real close to Ev and considered him one of my best and closest friends," Rushton says. "He was a fine man, and easy to bond with. I loved him like a brother."

When World War II began, Rushton (whose height and nearsightedness disqualified him from flight training) enlisted with the first group of non-flying engineering officers in the U.S. Air Corps. After his commissioning, he was stationed at Cochran Field in Macon, Ga., as engineering officer for a squadron of Vultee Vibrator BT-13A trainers. While there he learned that Leach had been posted to Turner Field, not far from Macon.

He drove down to visit Leach on Saturday, Dec. 6, 1941. The next day, Leach took Rushton up for a look around. "We were out over the Gulf of Mexico when we were contacted and told to return to base," Rushton remembers. "When we got back we were told of the attack on Pearl Harbor. I took off posthaste to return to my post in Macon."

Rushton and Leach stayed in contact. Rushton was transferred to Blythville, Ark., as technical inspector for a new training base. Both he and Leach were married, Rushton to the former Fran Young of Tacoma, Wash. They met up one last time in early 1943, when Leach and his wife, Della, stopped off in Blythville on the way to Dayton, where Leach would work in flight testing.

"That was the last I saw or heard of Ev until we got the bad news about the accident in England," Rushton says. "It sure shook us up, and we have also wondered exactly what happened." This winter the answer to that question finally arrived, like the reverberations from a distant thunder crash, echoing across the vast reaches of space and time.

Bringing a WPI Education Into the Information Age

By John Lott Brown '46

Twenty-five years ago, the faculty of WPI created an innovative, project-based approach to technological education. Today, the WPI Plan remains the core of our highly regarded undergraduate educational program. This year I have called upon WPI's faculty once again to display their creativity, this time by aggressively exploring and experimenting with today's communications and computer technologies—technologies that may have the power to greatly improve the effectiveness and the ease with which we deliver a WPI education.

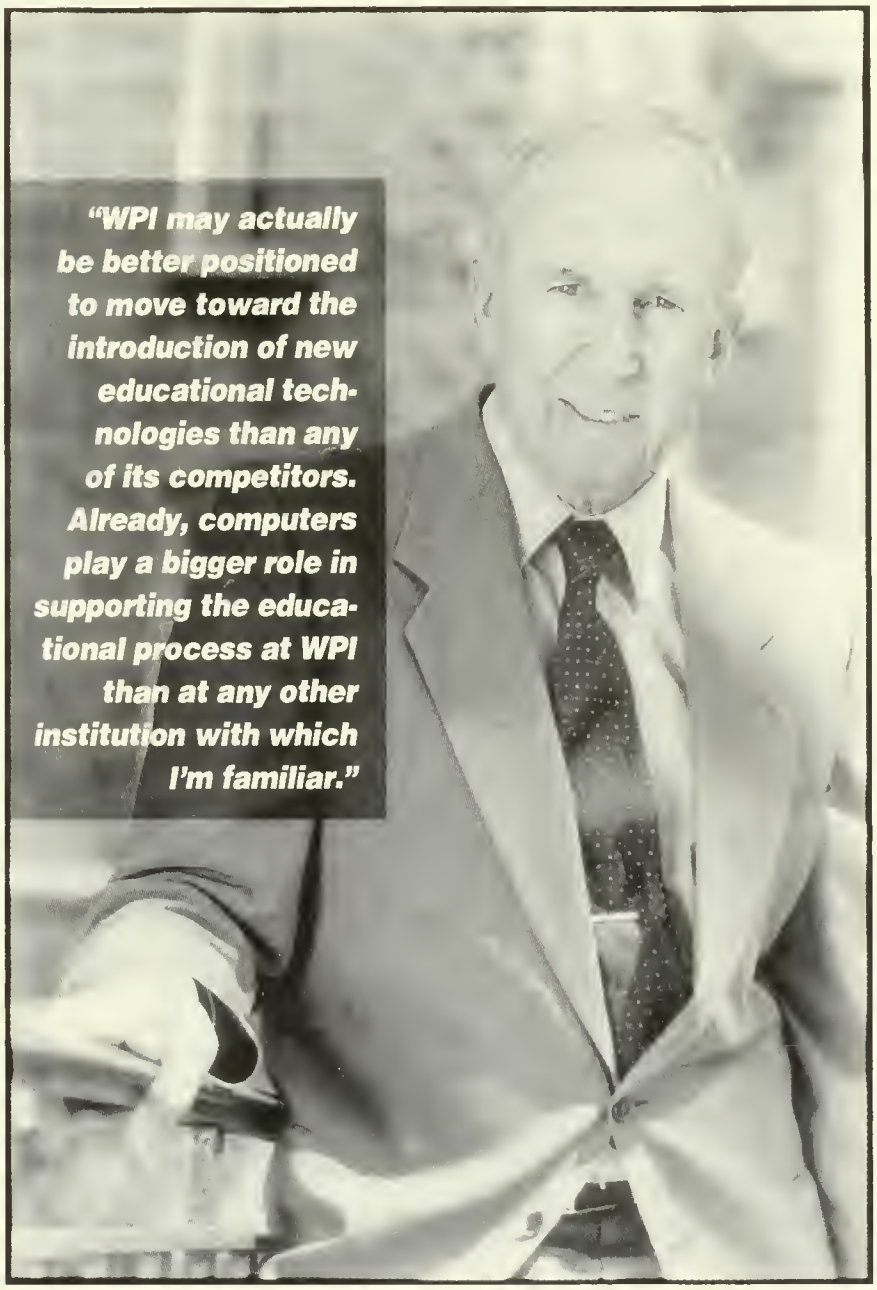


PHOTO BY JONATHAN KANNAIR

WPI is certainly no newcomer when it comes to using modern technology to enhance education. Not long after the Plan was implemented, Kenneth E. Scott '48, now professor emeritus of mechanical engineering, created the Instructional Media Center to capitalize on the educational potential of television. Many of the videotapes produced by the IMC over the years, including some made 20 years ago, are still being used to augment classroom instruction. But since then, while computer use has permeated the campus, the investigation of the educational use of new technologies seems to have stagnated. We have remained, essentially, a chalkboard culture.

The time seems ripe for getting back on track. Today we are seeing an explosion of new technologies, from multimedia, to virtual reality, to the World Wide Web. Clearly, these are developments that have the ability to transform the way we teach and learn. Already, many colleges and universities are devoting a great deal of time and energy to finding ways to use these technologies in their teaching programs. Many engineering institutions, for example, have formed coalitions, funded by the National Science Foundation, with the major goal of restructuring engineering education by developing innovative curricula, delivery systems, settings and pedagogies. Use of information technologies is a prime component of these efforts.

WPI must move vigorously to do the same kind of exploration, lest we be left in the shadow of competing institutions. If we don't act, we also risk losing credibility in the eyes of our most important constituency, our students. Prospective and entering students are increasingly sophisticated in the use of computers. It's reasonable to expect that they will also be enthusiastic about exploring ingenious "learning adventures" that make full use of ever more powerful computers and software. As we dedicate ourselves to this mission, we will reap benefits, both in attracting these students and in engaging their drive to learn.

WPI may actually be better positioned to move toward the introduction of new educational technologies than any of its competitors. Already, computers play a bigger role in supporting the educational process at WPI than at any other institution with which I'm familiar. Computers are available to students in virtually every residence hall room and hundreds of PCs and workstations are available in general access labs all over campus. But with few exceptions, the use of these machines is limited to the working of problems, the sending of electronic mail, and the preparation of reports.

There are only a few computer applications at WPI that can be said to replace the traditional role of the teacher. But these few examples prove that we have the facilities and the imagination to succeed in this new business of technology-enhanced education. What's more, these innovators are prepared to share their experiences and insights—won at no small expense—with the rest of our community. We already have at hand the experience, talent and facilities to make

it happen. We just need to bring these elements to the forefront.

No doubt, there will be obstacles to the broad implementation of educational technologies. And there will be significant delays before we see the benefits of this work in the form of improved education and reduced costs. Nonetheless, I am convinced that we should begin actively to explore broader use of educational technology at WPI. That is why I asked our faculty and staff to undertake three projects:

1. A compilation of advanced learning materials that are already available—both hardware and software. These include those that are free to anyone with access to the Internet and those that are sold commercially. We will also compile a list of consortia that have been formed to address the subject of new educational technologies and a bibliography of related materials, books and journal articles.
2. A preliminary effort to determine if suppliers of specialized equipment for learning technologies and software appropriate to education at WPI might be attracted to an instructional technology conference at WPI. (A conference is planned for October 1995.)
3. The formation of a committee to energetically explore the practicality of implementing a broad technologically based approach to education.

The committee has been formed and is moving ahead with all due speed. I have given its members my assurance that their efforts will be supported by me and my cabinet to the best of our ability. I believe that I can also assure them that the WPI Board of Trustees will support this endeavor (financially, if need be), because, if successful, it could prove dramatically beneficial to the Institute.

Implementation of sophisticated, state-of-the-art teaching and learning technologies could preclude the erosion of quality education that would almost surely occur if we were to continue passively, under the pressure of budgetary constraints, our traditional classroom methods. Most important of all, we could make our educational process more effective, and align that learning process with the interactive learning experiences of our 21st century students. What a dramatic complement that would be to the 25th anniversary of the WPI Plan!

—Brown is interim president of WPI.

Will the "New WPI" Be a Downsized University?

TO THE EDITOR:

We have just finished reading the *WPI Journal* article titled "Repositioning the Institute" (Fall 1994). As both alumni and parents of an incoming freshman, we feel we must respond.

We have been contributing alumni since graduating more than 20 years ago. We have followed the development of WPI over these years and agree with the six goals outlined in the Institute's strategic plan. Even the recommendations of the Blue Ribbon Task Force show insight into the need for keeping WPI current with the broadening needs of technology by including more humanities and social/political sciences. Our impression was that the focus was always on engineering and applied sciences: to provide the leaders for tomorrow's technology.

After reading the above-mentioned article, we are concerned that the Institute's "new direction" will be that of a downsized "university." In other words, it will be a place for those who choose to achieve a mediocre education in a wide variety of disciplines. This is not to say that a university cannot have an excellent engineering program. Many do, but only because they are so large that they can find both the people and the resources to have some excellent core programs. Please don't fool yourselves into believing this can be done on a campus of 2,700 undergraduates!

It is interesting that the basis of these recommended changes is a survey looking at why students who applied didn't choose WPI. This was followed by the rationale that if WPI can be more appealing to a wider variety of students, then it can be more selective and choose more students who can pay. What about the students who did choose WPI? Do you really believe it was because WPI offered better financial aid? We certainly don't! Most likely their reasons were based on curriculum, reputation and campus amenities. Experience tells us that large changes in programs will turn more students of "paying caliber" away than they will attract. Who wants to go to a college (or "university") that is unsure of its purpose?

Reviewing the five hypotheses of "The New WPI," we believe that items 2 and 3 [offering a professionally oriented master's degree students could earn with one additional year of study; developing preferred supplier relationships with employers of WPI graduates] are very important to WPI. Item 1 [developing programs in pre-health professions, environmental studies and other high-demand areas] is already being done, but just needs to be emphasized more during recruitment.

Item 4 [accelerating efforts to build a campus center; improving the gender, racial and cultural balance among students, faculty and staff] is a social mandate that could overshadow all other efforts of WPI if it is given too much importance; besides, WPI already has a good cultural/racial/gender balance for a private technologically oriented school. Item 5 [changing the Institute's name to WPI University] is simply a marketing ploy that could easily do much more harm than good. It could turn off potential "paying students" who are searching for a smaller technological school. From reading the section of the article titled "Comprehensive Campaign," we feel that the main emphasis of the next campaign will be a building program focused on item 4. (We get the impression that you feel appearance is worth more than content.)

"Experience tells us that large changes in programs will turn more students of 'paying caliber' away than they will attract."

Finally, our personal concern centers around our son's recent decision to attend WPI. He chose it as an engineering and applied science college. He will receive no financial aid (in other words, he will be a true paying student). He is not attending to participate in a "quality of life" experience. He could have gotten that much cheaper, and much closer to home. We attended WPI during the transition to the WPI Plan (as a matter of fact, we were both on planning committees our freshman year.) We saw firsthand how this change caused considerable turmoil and division on campus.

The change was right then, though it hurt many who could not cope. We fear that this time you will have more turmoil and division, and no good results to justify it. The end result of this could very well be the failure of WPI to provide students with the technological education that both they and the world need.

This article has caused us to be concerned that WPI's emphasis has changed from providing a quality specialized education to simply making money and appealing to the "in" crowd. If this direction had been set a year earlier we believe our son would have chosen a different school. We, most definitely, would not have been as supportive in his pursuing WPI.

Needless to say we hope we are wrong in our assessment of WPI's direction, and that WPI will continue to be a leader in developing high-quality graduates to be leaders in the technological arena.

— Bruce and Allison (Huse) Nunn '73
Spokane, Wash.

Neighbor Faults West Street Closing Plans

To the Editor:

As a citizen of the city, a neighbor of WPI approaching one-half a century, and a former paid consultant of WPI, I read with much interest the president's article on "Repositioning the Institute" (Fall 1994).

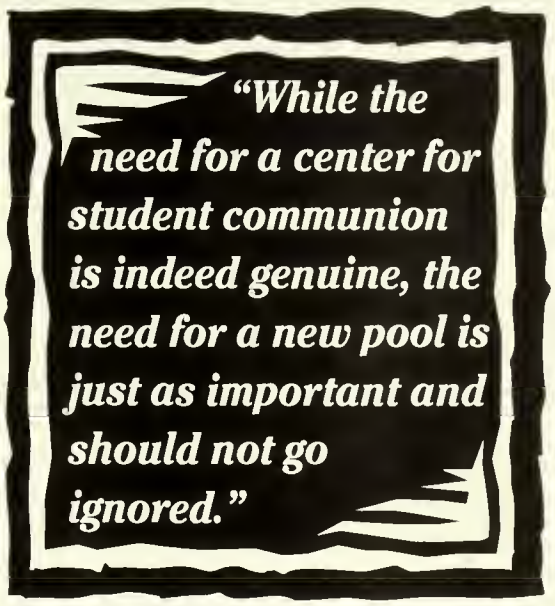
WPI must be complimented on finally developing a master plan. Just a few years ago the neighbors were invited individually to have a conversation with WPI executives and their consultant concerning neighborhood problems and the future goals of the college. When asked to discuss their master plan, the astonishing reply was that none existed. This appeared to us at the time to be a reflection on WPI's credibility or lack of long-range planning. Thus it is most reassuring to know that this great college, as recognized each year in *U.S. News & World Report,* has a vision and a plan for the future.

It should be stated that WPI, to a large extent, has been an excellent neighbor. It maintained, under President Jon C. Strauss, an open dialogue with neighbors, kept us informed of all activities, and included us in a number of campus events. The Institute, by its presence, has also maintained the values in the neighborhood and provided us with additional security by means of constant police patrols.

The neighbors support WPI as it progresses to university status and will cooperate in every manner possible. However, we ask that you review your master plan, not from an insulated vested interest viewpoint, but rather from the broad viewpoint of the common good. Off-street parking and the closing of West Street, as suggested in the plan to create a safer campus and an attractive pedestrian mall, must be addressed considering the concerns and interest of WPI, the neighbors and the community.

The automobile age has been with us since the beginning of the century and traffic congestion increases with each year. WPI is aware from past futile attempts to close West Street that it is a major concern of the neighbors and the city. One must consider that West Street is the only street from Park Avenue to the West Side Artery that connects Salisbury Street with Pleasant Street. To petition to close a short section of the street to enhance the beauty of the campus and to permit students to cross West Street between periods (for a total of an hour a day), 120 days a year, and deny the taxpayers the use of their street for the other 23 hours, 365 days a year, I submit is shortsighted and definitely not in the best interest of the community.

Additional traffic will be forced onto the other side streets surrounding WPI. Other solutions to this problem should be obvious, serving at the same time WPI's interests.



The other problem that exists in the neighborhood is street parking. As WPI addresses the problem of eliminating parking in the central campus and regreening the quadrangle, it must also address the number of automobiles that employees, faculty and students bring to the campus each day. City regulations require business and professional offices and apartment complexes to provide off-street parking. Should WPI be exempt from this regulation either by law or community obligation? The other nonprofit schools and hospitals in the city have solved this problem by providing off-street parking.

The use of resident parking permits, as suggested by the college, is not a solution. It only identifies the problem. The only solution is sufficient off-street parking for the WPI community. This priority should be as high on the list of capital improvements as the suggested student center. By the acquisition of a few additional parcels of land and the use of existing acreage, this problem could easily be solved.

As we approach the millennium, we look forward to cooperating, as good neighbors, finding solutions to these problems in order that WPI may implement its plan and vision. Then WPI will become the great university that is its destiny.

— John J. O'Malley
Worcester, Mass.

Make a New Pool Part of the Campus Center

To the Editor:

One of the lasting experiences of my undergraduate career at WPI was being a member of the WPI swimming team for four years and having the opportunity to swim at the New England Championship meet three of those years. Swimming was something I enjoyed, worked hard at, and got a lot out of. The key training facility for a swim team is, of course, a pool. A university swimming pool should serve as a practice and competition facility for the swim team and as a venue for physical education and extracurricular activities. It should be a place for students to gather and enjoy recreational swimming.

In recent years, much discussion has revolved around the need for a campus center at WPI. While the need for a center for student communion is indeed genuine, the need for a new pool is just as important and should not go ignored. Indeed, these need not be separate issues. It would be feasible to make a new pool a keystone of a campus center. This would be a way for the Institute to remedy one of its greatest inadequacies.

The current WPI pool is a grossly antiquated pit located in the basement of Alumni Gym. It was built in 1926, which means its 70th anniversary is fast approaching. Back in the 1920s, 20 yards was considered a good length for a pool. But today, pools must be at least 25 yards to be considered adequate by NCAA standards. Even the crudest pools are a minimum of 25 yards long and have at least six lanes. That is a

"bottom-of-the-line" pool. What WPI has is less than that. To put it simply, WPI's pool is an embarrassment to the swimming team and the WPI community as a whole.

The problems with WPI's pool include

- **its size:** The pool's 20-yard length has several consequences. WPI is the only university in New England that has a swimming program and a substandard pool. Practicing in this pool is one thing; being forced to compete in it is another. Other universities refuse to travel to WPI because our pool is of insufficient length. This means the WPI team has to travel more. Home meets must be held at Clark University, which has a regulation pool. Were WPI swimmers to compete in their own pool, they could never hope to qualify for the NCAA New England Championship, the pinnacle of the swimmer's season. The honor of attending this meet depends on achieving qualifying times. The more opportunities a swimmer has to qualify, the better his or her chances of making the championship.
- **its age and location:** Because it is buried in the bowels of Alumni Gym, many people at WPI have never seen the pool or even know of its existence. WPI doesn't try to show the pool off to visitors; guides wouldn't dare take campus tours down there. In fact, this inadequacy has turned away a good number of students—possibly more than can be readily quantified—who wanted to swim at a school with a "real" pool. A new pool would be an extremely attractive feature to prospective freshmen, even if they never used it. It would resonate the school's commitment to the total education of the individual.

WPI's swimming program has great potential. We have good athletes and a dedicated coach, but we cannot expect to attract quality swimmers with our current pool. Our divers travel to Holy Cross to train; our swimmers travel to Clark to compete. While every school we compete against has been afforded the proper facilities, we have become a laughingstock. (Even Assumption College, which doesn't even support a swimming program, has a new pool.)

With WPI's emphasis on academics, it is imperative that the Institute not overlook the social, athletic and extracurricular activities that are so important to the total human equation. With all the hype about a campus center, please do not ignore the fact that we need a new pool just as desperately. It is my plea that the next large construction project at WPI include a campus center with a new 25-yard, six-lane pool. Such a facility would provide a new dramatic focus for campus athletic and social life.

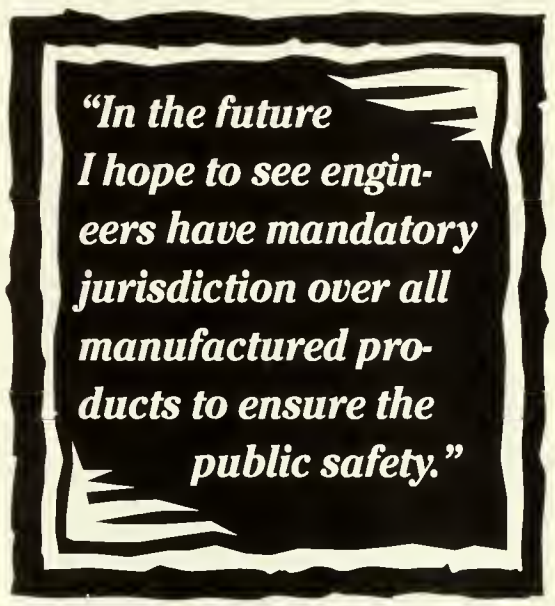
— Sean Donohue '93
Worcester, Mass.

The writer, now a graduate student in fire protection engineering at WPI, was captain of the men's swimming team in 1992-93.

Thoughts on Ev Leach and the F.E. Exam

To the Editor:

It was with considerable interest that I read the Winter 1995 issue of the *WPI Journal*, which included an article about my classmate Ev Leach and Nils Askman, with whom I shared structural engineering classes at Lafayette College in 1936-37. I spent two years at WPI and then transferred to Lafayette, where I took a reduced credit load due to a severe brain injury suffered while I was at WPI. Thus I went into the sophomore class with advanced standing that allowed me to take some junior-year subjects in structures. It was there that I met Nils Askman and thus had the privilege of studying with both of the men mentioned in the article ("The Search for Everett Leach"). I did not again meet up with either Ev or Nils after graduation. That these two men who had briefly touched my life should become close friends—what a strange quirk of fate!



My other comment deals with the letter of George A. Dainis '79 in the same issue concerning an article by Mort Fine '37 on mandating F.E. examinations before graduation ("Academia is Shortchanging New Engineers," Summer 1994). I must take issue with Mr. Dainis, who wrote that industry engineers do not require P.E. registration. It is true that currently such registration is not required in Massachusetts, but that is not true throughout the entire United States. In addition, it is only a matter of time before industry engineers will have to be registered to practice engineering, as more and more law suits are filed by consumers who have been injured by products produced by industry. The fact that a designer of an engineering project was not registered as a professional engineer is often a fact that juries take into account when it comes to awarding damages to plaintiffs.

I believe George Dainis is living in a dream world of 25 or 30 years ago and not in today's litigious society, where lawyers file "shotgun" suits against anyone connected with a case. Often it is the manufacturer who has the "deep pockets" that finally pays the settlement or judgement. Let the seniors take the F.E. exam as part of their finals and be done with it. In fact, most seniors are smart enough to do so.

— George Mallis '38 P.E.
Wilbraham, Mass.

A Note on the Title "Engineer"

To the Editor:

I enjoyed reading George A. Dainis' letter to the editor (Winter 1995). All the facts in his letter are correct. However, I would like to add that although an engineer may use the title B.S., M.S. or Engineer after his name, he cannot legally use the title Mechanical Engineer, Electrical Engineer, etc., without registration. In the past, all efforts to restrict the use of the title Engineer met with defeat due to the objection of special interest groups, such as contractors, designers, draftsmen, etc. Support is needed from all engineers to solve this dilemma.

I believe the most important reason for all engineers to register is not for immediate career advancement, but for future increase in the status of our profession. I predict that with enough engineers registered, thus obtaining legal status, they will get more authority in critical corporate decision making. Right now, in most companies, people other than engineers are determining the final design, safety, price and so on of products. Sometimes their decisions are based on company profit, rather than on engineering. The Challenger disaster and the Los Angeles MTA subway tunnel fiasco are just two cases in point. In the future I hope to see engineers have mandatory jurisdiction over all manufactured products to ensure the public safety.

— Victor Chun '51 P.E.
Los Angeles, Calif.

Serving the Adult Learner

By Michael Dorsey

If you teach it, they will come. That's what WPI's Office of Continuing Education discovered last year when it decided to offer a certificate program in UNIX and C programming.

UNIX is an operating system commonly found on time-sharing computers in industry and academia; C is a programming language well suited for a wide range of engineering, science and business applications. While UNIX and C have long been popular among computer science majors and technical professionals, the Continuing Education Office wondered if there might be an untapped market for courses on these topics among New England's high-tech work force.

"We did a feasibility study in Massachusetts and discovered that there is a great deal of interest among manufacturing and service companies, financial services firms, hospitals and other employers in migrating from other operating systems to UNIX," notes Arlene Lowenstein, director of continuing education. "Since UNIX runs on distributed workstations, it can lower a company's investment in computer hardware, and it requires less support staff than other systems. There appeared to be a real demand for high-end training programs to prepare working professionals for this shift."

In 1994 the Certificate Program in UNIX System and C Programming became the inaugural offering at WPI's Technology Education Center in Westboro, Mass., a new satellite facility established to serve the high concentration of information system professionals in the Greater Boston and Central Massachusetts areas. More than 130 people enrolled in the first year of the program, in either the eight-week full-time or the 26-week part-time classes.

The UNIX/C program is just one of the ways WPI is responding to a significant change in the demographics of the American college population, Lowenstein says. "According to the College Board, part-time students now make up 45 percent of all students enrolled in colleges across the country. Students 25 and older account for half of all college credit students and half of all graduate students."

"To stay current in their fields, men and women today need to continually renew their knowledge."

In part, this shift reflects the rapid turnover in technology, which makes even the best technical education a perishable commodity, notes WPI Provost Diran Apelian. "The 'shelf-life' of a science or engineering education grows shorter every year," he says. "To stay current in their fields, men and women today need to continually renew their knowledge. WPI has always placed a great emphasis on lifelong learning—it is, in fact, one of the hallmarks of the WPI Plan. A few years ago, we made meeting the lifelong learning needs of the region's professionals one of our highest priorities and codified it as Goal 5 of the Institute's strategic plan."

To serve those needs, WPI now offers a wide range of programs, including the evening graduate program, the School of Industrial Management (now in its 46th year), and courses and workshops offered at remote sites with "live" instructors or by videotape. WPI also delivers programs at several corporate sites using compressed video technology.

The Continuing Education Office offers more than 80 public seminars annually in three broad areas: product management, quality improvement and management development. "Our most popular quality programs today include statistical process control, failure mode and effects analysis, and geometric dimensioning and tolerancing," Lowenstein says. "And as more and more companies go to team-based management, our courses in leadership, team-building, coaching and management skills will be in greater and greater demand."

More and more, she adds, corporations, recognizing the benefits of having an up-to-date work force, are asking the Continuing Education Office to organize workshops specifically for their employees. This year Lowenstein's office will run at least 60 such corporate training programs. One of the longest running is the Nypro Leadership Institute, a weeklong workshop held at WPI that has been attended by more than 150 employees of the Clinton, Mass., company.

The newest initiative of the Continuing Education Office is a series of technical short courses to be offered on campus this summer. "The short course series is an exciting new direction for us," Lowenstein says. "Like our public seminar series, the short courses are designed to help working professionals update their knowledge and skills. But they will also showcase WPI's outstanding faculty and focus on new developments in technology and science."

In all, 19 courses in civil and environmental engineering, computer and information sciences, electrical and computer engineering, fire protection engineering, management, manufacturing engineering and materials science, and mechanical engineering will be offered between early June and late August. The leading-edge topics include design and construction integration, ultrasound in medicine and industry, design for manufacturing and assembly, and the mechanical properties of biological tissues. A special one-day course on using the Internet will also be offered.

"The market for lifelong learning is growing, and more and more, professionals will be demanding new and innovative programs—like this short-course series—to help them be successful in this rapidly changing world," Lowenstein says. "This is truly an exciting time to be in this business."

For more information on WPI's continuing education programs, call 508-831-5517. A full schedule for the summer short course series, along with detailed descriptions of any of the 19 courses, will be mailed or faxed upon request. Information on continuing education programs is now on the World Wide Web. Point your browser to http://www.wpi.edu/Depts/Admin/CE/ to reach the Continuing Education Home Page.

Blowing Away Goose Tatum

On Jan. 17, a massive, 7.2 magnitude earthquake devastated the city of Kobe, Japan. Half a million buildings and homes were destroyed, 5,422 people were killed, and the lives of many thousands of others were thrown into turmoil. Among those who felt the wrath of the Earth that day was a WPI history professor. Here is his first-person account of life during and after the Kobe quake.

By John Zeugner

AP/WIDE WORLD PHOTOS

The Kobe earthquake toppled the Hanshin Expressway, which connects Kobe to Osaka. Inset: the room in the Kobe College Alumni Building where Zeugner and his family spent several days after the quake.

Proper Prayers

It is about 8 p.m. on the fourth day after the quake. We're on the second floor of the Alumni Building at Kobe College, where we were moved after our house was condemned. Alice and I and the children, Emily, Max and Laura Ruth, have been sleeping on the floor of a classroom, where the desks have been shoved into one corner and carefully roped together in case of severe aftershock. Now five more refugees have joined us in this room. We step around the futons on the linoleum.

Mary Ewald, a missionary teacher at Kobe College High School, has come back from Kyoto with another missionary, a friend who has been putting her up for the past few nights. The friend suggests we pray together. We form a circle and the friend leads us in prayer: "Oh, Heavenly Father," she begins, "we give you praise and thanks for sparing us in this time of trouble."

Alice and I look at each other. Praise and thanks? Who, after all, sent this time of trouble? "Oh, Father, in your endless goodness you have seen fit to bring us here together and to provide us with food and water and safety. We thank you profoundly for that succor in the midst of this tragedy." The theme is uniform: praise and thanks, thanks and praise. The litany runs on and on. My children shift from foot to foot. I begin to wonder if the missionary visitor has gotten into some kind of rhetorical bind, or does she sense a certain resistance to her message and hopes to wear us down through repetition?

Later I ask Alice, "What did you think of the prayer?" She answers, "Heavenly Father, get a grip! You've almost sacrificed your most loyal servants. What is going on here? Get a grip!"

And there is survivor guilt—5,400 died and we did not. Why? Over the green pay phone in the building lobby my colleague at International University of Japan senses my unease. "John," he says calmly, "you want to know why you survived and others didn't? Is that what's bothering you? Well, I'll tell you why. Your house was stronger and had more rock under it. That's why, and that's all it means."

The Gymnasium Shivers

Four hours after the quake, we, along with the students who resided in the collapsing dormitories, were required to move to the gymnasium, perhaps the sturdiest building on the Kobe College campus. About 300 female students and the five of us took up residence on the polished wood floor. Overhead there were immense white painted girders holding up the roof.

How quickly we adjusted. I decided that if this was to be our new home, we should stake out a section along the side wall. At least then we'd be able to sit on the floor and lean back against something. The students, still in their pajamas and wrapped in blankets, formed eddies on the floor. Plastic liter bottles of orange juice were passed around periodically and a plastic bag of rolls went from hand to hand.

At the entrance to the gym were two kerosene heaters, but they were inadequate for the job of keeping the vast space warm. Of course there was no water or electricity, and the only operating

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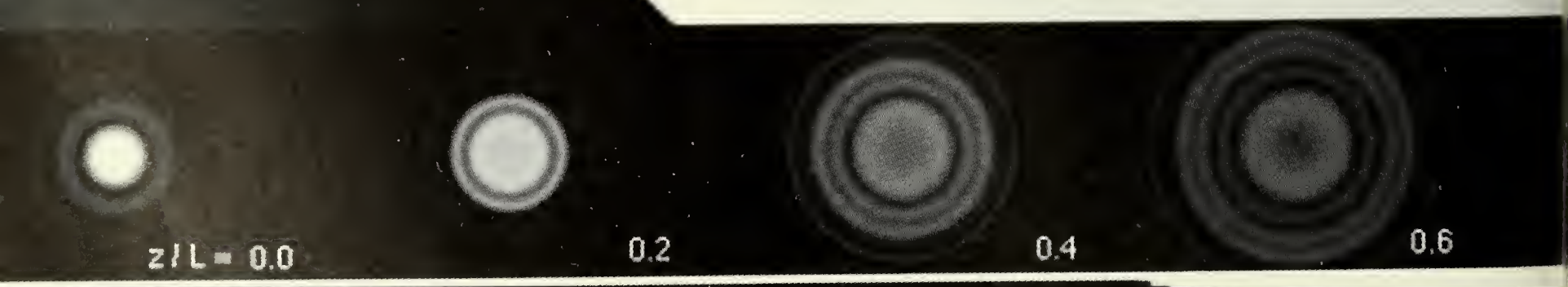
THE LIG



The progression above shows a laser beam rapidly diffracting in a "defocusing" material, a phenomenon that may help protect eyes and sensors from laser damage. The background pattern is part of a computer-generated spiral phase profile of an optical vortex soliton, one of Swartzlander's discoveries. Portrait photo by Patrick O'Connor.

HT FANTASTIC

In Grover Swartzlander's lab, light can alter the properties of materials, it can be molded into stable stripes and grids—it can even be twisted into corkscrew-like vortices. Welcome to the brave new world of nonlinear optics.

By Michael W. Dorsey

In the early 1980s, Grover A. Swartzlander Jr. was a research assistant at Purdue University, working in a laboratory he set up with Alexander Kaplan, a Russian-born professor of electrical engineering. Under Kaplan's supervision, Swartzlander was passing beams of high-intensity laser light through sodium vapor and looking for unusual optical phenomena.

"Sodium vapor is a good medium for studying optics," he says. "In high school and college physics labs, students often study the sodium spectrum because it radiates an exceptionally brilliant orange color. We were looking for nonlinear phenomena and were seeing some strange and beautiful patterns of light. We began placing different materials in front of the laser and watching how they affected the diffraction of light in the sodium vapor. We saw some weird things—shapes that looked like lobsters or guitars. It was like taking a Rorschach Inkblot Test.

"At one point we put a very fine mesh screen in front of the laser. This time we didn't see a crazy pattern. Instead, we saw an amazingly well-organized array of square spots separated by dark lines. I found it quite beautiful and intriguing. Under low-intensity light it would appear to be a simple diffraction pattern. But under high-intensity laser light it would form an arrangement of spots that was unusual and distinct. We figured there had to be something fundamental going on inside that material."

What Swartzlander had observed would come to be called dark soliton stripes and grids, a new twist to the already twisty field of nonlinear optics. Just two decades old, nonlinear optics is the study of what happens when high-energy beams of light pass through materials. Unlike the low-power light we encounter in everyday life, the intense beams from lasers can alter the properties of the materials they pass through. Those altered properties, in turn, can affect the characteristics of light in an intricate *pas de deux* that produces some remarkable results.

But the byproducts of nonlinear optics are far more than laboratory curiosities. In fact, the field is poised to revolutionize the computer and telecommunications industries. By playing some of the same tricks with light that semiconductors play with electrons, nonlinear optics should drastically increase the capacity of phone lines, produce much faster and more efficient computers, and pave the way for a host of other 21st century technologies.

In this hot new field, Swartzlander is considered a rising star. The significant and often-cited work of his first decade in the research lab, coupled with his potential for future achievement, earned him a 1994 National Science Foundation Young Investigator Award. He was one of only about 180 of the nation's top scientists and engineers to receive the honor last year. In addition to prestige and national recognition, the award can bring recipients up to $500,000 in government and corporate matching funds over a five-year period.

Swartzlander joins three other WPI faculty members in receiving the NSF award, which was previously known as the Presidential Young Investigator Award. James E. Rollings, associate professor of chemical engineering, won the honor in 1985. In 1991 it went to Tahar El-Korchi, associate professor of civil engineering, and Peter L. Levin, associate professor of electrical and computer engineering.

(Continued on page 17)

Good

From earmuffs that shut out the roar of jet engines to high-tech traps that snare mosquitos, WPI's Acoustics Laboratory has been doing remarkable things with sound for more than 50 years.

On a pleasant spring afternoon, three men gather inside the large, ornate garage next to Higgins House on the WPI campus. For more than two decades, the garage has been home to the WPI Acoustics Laboratory. Today the small lab is packed with the tools of the acoustical engineer, from a huge steel reverberant chamber to a state-of-the-art digital tape recorder smaller than a paperback book.

One side of the lab is dominated by a rack of oscilloscopes and electronic instruments. Before the rack is a table, over which the three men now hover. On the table sit several plastic cups, their lids carefully fastened with white tape. A larger cylinder is attached to the end of a small boom that is, in turn, secured to a tripod. Both ends of the cylinder are covered with a fine mesh and three small holes in its side have been sealed with overlapping layers of latex. The business end of a small microphone has been inserted into the cylinder through one of these latex valves. When everyone is still, the room grows exceedingly quiet and you can just detect the high-pitched whine of a mosquito.

Sam Martin, an entomologist with the U.S. Army Walter Reed Medical Institute, pushes a plastic tube through a latex valve on one of the plastic cups. He places the other end of the tube between his lips and draws in some air. When he withdraws the tube a few seconds later, it contains a small, grey, wriggling mass. He pushes the tube into the larger cylinder and blows gently to flush out the mosquito. "This is *Anopheles freboni*," he announces. "This one transmits malaria."

With the tiny insect isolated, Richard Campbell '58, adjunct professor of electrical and computer engineering, and William Michalson ('85 M.S.; '89 Ph.D.), associate professor of electrical and computer engineering, turn on a tape recorder. For more than an hour, the recorder turns while the mosquito, prodded by taps and puffs of air, takes brief, buzzing flights. The recording is one of many the three men will make of several mosquito species that together comprise a sort of medical "most wanted" list. They include

the insects that are the prime vectors for malaria, yellow fever and encephalitis, among other diseases.

The project, funded as a pilot study with a $10,000 grant from Walter Reed, has two goals. One is to find a way to use the mosquito's own homing ability against it by building a high-tech sound trap. The other is to automate the process of identifying mosquitos in the field—essentially capturing the expertise of an entomologist in a hand-held device. "The female of every mosquito species has a unique wing-beat sound," Campbell says. "It's this sound that attracts the males for mating. If you can reproduce this sound accurately and play it through a loudspeaker, you can draw all the males in and kill them or send them back to their nests dusted with poison, where they can kill even more mosquitos.

"Perfecting an aural mosquito trap has been a dream of medical scientists for more than 50 years. While there have been some successes during that time, we believe that with state-of-the-art, multimedia, direct-to-disk recording and editing technology, and the sound-synthesizing equipment we have today, we can probably build a much more effective mosquito trap."

Just as exciting, Campbell says, is the ability to identify a mosquito species solely from its sound signature. To avoid spending hundreds of thousands of dollars manufacturing and transporting perishable vaccines it doesn't need, the U.S. Army sends advance teams of entomologists to sites of likely future military engagements to sample the local insect life and determine which diseases will pose threats. "But as a result of cutbacks," he says, "the Army doesn't have enough entomologists to do this work. So Bill Michalson and I thought that we could build a hand-held box into which you could place a mosquito, push a button, and see a display identifying the species. That's something any lieutenant could do."

Central to the success of both projects is the application of modern acoustical engineering techniques. With their digital tapes of mosquito sounds in hand, Campbell and Michalson head for a lab on the second floor of Atwater Kent Laboratories to feed the data into a computer. Using sophisticated software,

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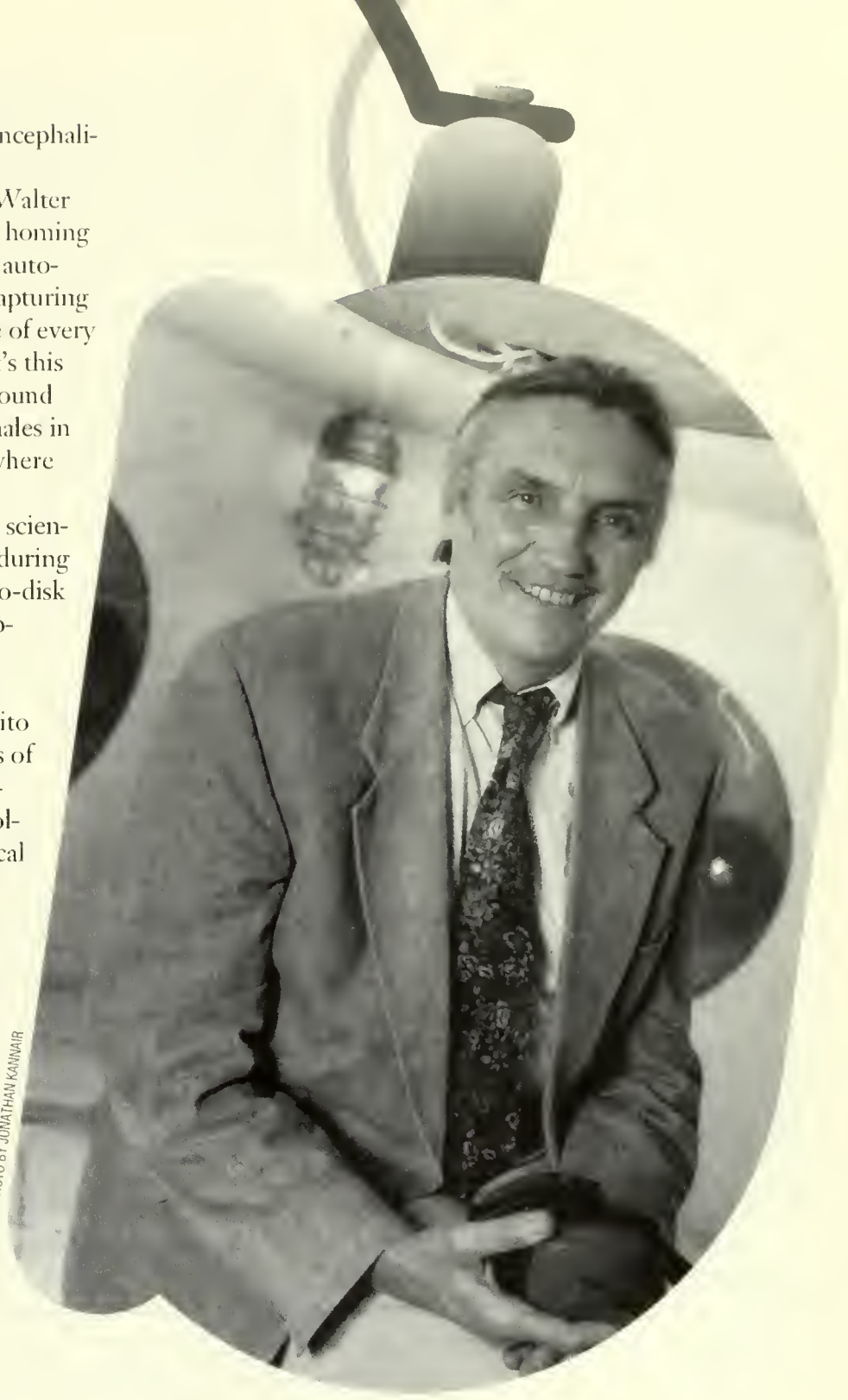


PHOTO BY JONATHAN KANNAIR

Opposite, William Wadsworth with test subject Richard Beschle '50, who founded WPI's Biomedical Engineering Program. Above, Richard Campbell. Below, a graph of a mosquito wing-beat sound.

Vibrations

By Michael W. Dorsey

toilets were those outside, adjacent to the swimming pool. You took a bucket and filled it up from the pool, and then used that water to flush the toilet.

Some of the students enjoyed talking Japanese with my youngest daughter, Laura Ruth, who attended a Japanese kindergarten. For about an hour we sat dazed on the floor listening to the conversations. Periodically, Chaplain Shigeru came in to announce that now it seemed that 1,800 were dead, but that the number was climbing; that the Hanshin highway had turned on its side; that the Hankyu railway was totally out from our city, Nishinomiya, all the way to Kobe Center; or that fires everywhere were out of control. But mostly there was the hubbub of 300 students explaining to each other what had happened and listening to each other's amazement.

AP/WIDE WORLD PHOTOS

Fires rage throughout Kobe in the immediate aftermath of the magnitude 7.2 quake.

And after a while, the brilliant, crisp sunshine outside seemed to indicate that nothing further could happen—that after this initial dark massacre, all would eventually be repaired. We thought about just leaving the gym and going back home; there was no water, gas or electricity there either, but at least there were chairs, a well stocked refrigerator, and familiar, if broken, dishes. And we would have done so, but at 9:52 a.m. came the first aftershock.

The girders overhead shivered. Frosted glass lining the left side of the entry to the gym simply splintered outward and fell onto the floor near the heaters. The girders lifted, settled, shivered again, and then stopped moving. The gym grew stone silent. The orange juice and rolls stopped circulating. No one spoke. Laura Ruth curled in a fetal position on the floor, put her hands over the back of her head, and then turned her face to me. "Is this when we die?" she asked. "I don't think so," I answered.

Technology's Insane Juxtapositions

On the third day we discover that the Hankyu Railway has opened a line from Nishinomiya-Kitaguchi to downtown Osaka, Japan's second largest city. Colleagues have found a public bath in Osaka and the lure of hot running water is irresistible. It is a 20-minute walk through rubble to get to Nishinomiya-Kitaguchi, and the crowds there are dense, unfriendly, shoving. But soon enough all five us are on a familiar, clean, velveteen maroon Hankyu train and moving swiftly toward Osaka.

At Umeda Station the platforms are familiar and crowded, and the hordes familiar and normal. The swift passage, the moving walkways, the gleaming neon, the buildings intact—all normal, as usual. It is like Christmas morning; everything works. The restaurants and coffee shops are filled. There is no damage here; nothing has been interrupted.

Only a few refugees in the public bath can share our sense of the realities 40 minutes away. No one cares about life in the "zone of destruction" to the west. This is the Japan we used to know—safe, clean, sparkling, rich, sophisticated, self-possessed, hard to penetrate, but boundless in its rewards for that penetration. What quake and where? We soak in the hot tubs, splash the hot water, triple-rinse our hair. We towel off in the thick mist; dry in the hot air. We dress again and have tonkatsu, a breaded pork dish, in our second favorite tonkatsu restaurant.

In Umeda Station we stop off at Kinokuniya Bookstore, browse the English magazines and books, and buy a few, pretending the "zone" isn't there. And then, 22 minutes on the local train and 20 minutes walking brings us back to no heat, no water, no light, no food, no life. Max and I put down the magazines and books, take up the empty pots and pans, and walk down to get in line for water from a broken main in the roadway running along the foot of the campus.

Media Games

At 2:30 a.m. on the morning after the quake a phone call got through from Dennis Benton, an old friend at London's BBC World. He wanted to know how we were, but his boss wanted to know, "How was it, and what will you do?" After Dennis, I got passed to an "interviewer" who "prepared" me for "the presenter."

"He will ask essentially the same questions I'm asking, so let's just run through them, shall we?" the interviewer said. "Yes," I answered. "I was in my underwear when we sprinted outside, afraid the house might explode. Alice was up cooking, using the stove, and she had turned on all the gas space heaters. Yes it's quite cold; in the 30s, in fact. Of course there is no heat, no water, no electricity." Just this odd phone, I thought. I recounted the trip to the gymnasium, the return to the house, the appearance of the house and those of several colleagues that were damaged far worse than ours.

All this was familiar, a glib recitation. The first two interviews with presenters went off easily. The BBC called about every three hours after that. When I was out they talked to Alice or to the Bannerjees, colleagues who teach at Kobe College and who moved in after their house collapsed.

But by the third interview I sensed a certain edge in the presenter's voice, and the questions grew more direct. "Are you angry with the Japanese government for not doing more?" I was asked. "Not really," I answered. "They seem to be doing as much as anyone could under the circumstances." "Don't you know Japanese who are angry with the government? Is there no resentment against the lack of water, the lack of fire-fighting facilities?" "Not really. The Japanese are resilient and self-possessed, above all dogged in their determination not to complain." "Well, thanks for talking to us. We'll call again later."

Afterwards, in discussions with Alice and the Bannerjees, I decided the media was not happy with our responses—it was, in fact, beginning to filter out our data, our modest contributions, since the data did not match the on-going story of incompetence and resentment. So here was the "Braestrup Thesis" illustrated once again. In *Big Story*, Peter Braestrup argued that media analysts, editors, commentators, reporters and writers tend to coalesce on a scaffolding of a story, and by the third or fourth day want only data that supports the story. Accuracy is not the issue; support for the story is the issue.

Thus, Braestrup argued, the Tet Offensive during the Vietnam War was actually a victory for the Americans and the South Vietnamese, but by the third day the media had decided the "story" was defeat—catastrophe for the Americans and the South Vietnamese. The counter data was shut out. The media convinced the public that Tet was a disaster. Support for the war evaporated; the President, in effect, abdicated; the opposition party won the election; and the war concluded with an ignominious American exit. All because the media understood the "story" to be disaster.

The story of the quake in the U.S. media became, apparently, the story of incompetence and resentment—a new variant of Japan bashing. The absence of looting; the infinite Japanese patience through adversity; the determination to stick by dead relatives; the civility in the midst of despair—these were peripheral to the "story" of incompetence and resentment. The Western lens wanted to see rage and it tirelessly swung back and forth above the action to fix on confirming anger. They sought a mother lode of rage, and not finding it in conversations with us, moved on to more manageable news.

The Japaneseness of the Response

The government did make errors—predictable, horrible errors. Government by consensus means government by delay, by irresponsibility, by failure to lead, by bureaucratic standard operating procedures. No one expected a Kansai quake. No one planned for Kobe to be the center of such a disaster. Everyone knew the great quake would be in Tokyo, and will still be in Tokyo. Tokyo, someday, inevitably, will be destroyed. Unlike San Francisco, which plans ahead for its doom, Kobe had no independent water system. It had not enforced Japan's 1981 earthquake construction codes on older houses, especially in areas traditionally shunned by Japanese, such as the Korean ghettos and those places occupied by Japanese Eta or Burakumin, descendants of butchers and leather tanners.

Kansai did not have severe quakes. Kanto had them. Hokkaido had them. Kansai did not have them. When I lived in Tokyo in the early 1980s, I knew the big one was coming because small ones occurred so frequently. Earthquake directions were printed on posters everywhere—in English and in Japanese. In Kansai it was not an issue. It could not happen there. Even when it actually did, it still could not happen.

Right away, Switzerland offered its trained dogs to sniff out survivors in the rubble. Japan declined, but then 12 hours later realized the error of that decision and rescinded it. Switzerland sent the dogs and handlers. They landed at Kansai International Airport, where they ran amuck of the Ministry of Health and Welfare, which insists that all dogs coming into Japan be quarantined for a very long time. Another day passed before the rule was waived. The Swiss dogs found corpses, not survivors, in the rubble.

And then there was the refusal of American flu vaccine. Refugees living in school shelters were vulnerable to infection. Flu soon enough flooded over them, but the Japanese turned down American flu vaccine as "inappropriate for Japanese." In Japan the key distinction is always between the inside and the outside. Those inside share, support, consent; those outside merit nothing. Public rudeness astounds Westerners, just as private graciousness amazes them. But in catastrophe, Japan is the inside and everything else is the outside. The Americans were dumbfounded to have their flu vaccine refused. But it was as if Rumania had sent special vaccines for the Northridge, Calif., victims. Who in America would have embraced Rumanian vaccine? Who in Japan would have embraced American vaccine?

AP/WIDE WORLD PHOTOS

A member of Japan's Self-Defense Force stands guard over a devastated section of Kobe.

Necessary Denials

In the first eight hours after the quake, Chaplain Shigeru becomes the sole authority figure. He comes to the gym to tell us what is happening. The work crews report damage to him and he reports to the multitudes without homes on campus. By early afternoon he indicates to us that our home has been inspected and has been pronounced safe. We should return to it and await further developments.

The prospect of days in the gymnasium have become grim and it is welcome news that we can go back home. Soon enough, our house, as the only standing unit of faculty housing, becomes a refugee center. The Bannerjees move in, as do Lisa and Brian, Misa and Mary, and sometimes Greg and Vic and Jozef.

Twice a day for three days, I ask Shigeru if the house is safe. I point out that the pillars holding the upper balcony and roof of the house have shifted half off their pilings. I mention the cracks opening in the walls. I note that ceilings seem to be lower-

ing, so that sliding doors on the first floor become harder and harder to open. Is it wise to have 13 people sleeping in such a structure? And always, Shigeru is prompt, authoritative and reassuring: the house has been inspected—it is entirely safe.

I keep asking when the inspectors came by, because we have nearly always been in the house. We surely saw no such inspectors. If they had inspected while we were at the gym, might they not need to reinspect now? It is not necessary, Shigeru insists. The house is safe, and it is continuously being monitored. By whom and when? I wonder.

Then on Thursday, the fourth day after the quake, two youngish Japanese in hard hats show up. Structural engineers. They walk through the house, pausing at the shifted pillars along the front, pausing even longer at the fissure line in the foundation, measuring the widening cracks in the rooms, and tell us, "Get out of the house immediately. It may very well come down in the next aftershock."

We gather a few things and move back to the Alumni Building. On the way there I see Shigeru near the gymnasium. I run over to him. I am carrying my futon and some oranges in a plastic bag. "House inspectors finally came today," I say in my most chastising tone, "and they said the place is unsafe. They ordered us out immediately. There hadn't been any inspection. When they finally inspected, they said the building was completely unsafe. But there were 12 or 13 of us sleeping there. You said the place was safe, but it wasn't safe. So you just li...."

AP/WIDE WORLD PHOTOS

Quake survivors pass rail tracks in the city of Nishinomiya that were twisted by the force of the quake.

Shigeru, eyebrows bunched, cuts me off with a single word, uttered with amazing equanimity and panache. "Good!" he says. It is a silencing response, made up, I decide later, of several parts: One portion is the sentiment that whatever is standing is safe. Another is his desire not to have these gaijin underfoot and within infecting proximity of Kobe College students. Yet another portion consists of simply saying whatever it is these gaijin need to hear to be done with them. There is also a portion that admits that at some level, what is spoken in English to gaijin need not conform to truth.

Over the next several days it also becomes clear that damage recognition is not an easy issue for educational institutions that want to remain competitive for a declining student pool. Admitting heavy damage could undermine the college's attractiveness. I hear indirectly that the administration is furious when a Japanese magazine, within a week of the quake, produces a picture book that features an aerial photo showing the collapsed roof of the literature building, where my office had been. Such pictures discourage applicants.

Sirens and Helicopters

From the second hour after the quake until we got to Kansai International Airport in Osaka Bay, there was a continuous sound of sirens. Only their loudness varied; they never stopped. In retrospect, the wailings were an announcement and endless iteration of pain—the squealing of crushed and torched humanity made bearable by the mechanical, electronic distancing of the noise. From the fifth hour, the sirens were joined by a more ominous thudding—helicopters endlessly churning overhead.

For most of the first day I believed that the copters had to be media-related. Their whirlings jiggled the house, but seemed a pale imitation of the 7.2 roar some hours before. By the third day we had adjusted to the noise—filtered it out, partially. We knew we could get some kind of water, some kind of electricity, and, because of Osaka's proximity, some kind of food. "We survived," Alice said, "but I wonder how we'll live."

My daughter Emily, because she had turned 16 and knew she was immortal, because she had no phone access to her friends, because it was becoming clearer and clearer that she would not get a chance to go back to her school in Kobe, because she was bored and edgy, begged to use one of our bikes to try to reach classmates about an hour away. When Misa, a missionary teacher who had temporarily come to stay in the house with us, also needed to bike to Ashiya, we let Emily go with her. It was, after all, a warmer, brilliantly clear day, and in the sunshine, in the mucid soft caressing nature of Japan's mild winter, it seemed that aftershocks were impossible—all damage over, all destruction done.

It was an idiotic decision, one we regretted the minute Emily was out of sight. Time passed quickly enough. Mr. Hata came in from Kyoto with a dozen Egg McMuffins, manna itself. Professor Ueno came in from Osaka and dropped off three gas canisters for the portable burner. Laura Ruth played outside on the concrete apron fronting the house, despite the shifted pillars. The house shuddered in the copter passings. Each siren seemed to chastise a parent for letting a young girl go off on a bicycle in such circumstances.

Emily had planned to be back by 4 p.m.; 5:30 came and went. If she had had an accident, I thought, there would be no way to help her. More sirens, more helicopter thuddings. And then the blessed sound of tire spin on the roadway and onto our driveway. Emily and Misa were back. "Dad," she said, "you thought they were part of the media." She pointed to the noise overhead. "They're not. They're taking bodies out in bags and coffins. That's what they're doing. We saw them loading and loading." She burst into tears.

Blowing Away Goose Tatum

Forty-five years ago I lived to watch the Harlem Globetrotters. In particular, I followed the gyra-

tions of Goose Tatum. Sometime midway through the first quarter of every game he'd drop back and begin to do his astounding dribbling act, clipping the ball along at about four inches off the floor. Opposing guards made inevitable challenges, but Goose simply dribbled through them, around them, between his legs and theirs, circling, doubling back, always with the rat-tat-tat of that microdribble, machine gunning the ball, in amazing control, in dazzling figure eights across an expanse that clearly was entirely his domain.

At 5:46 a.m. on Jan. 17, a jet-engine, superdecibel roar from the center of the Earth spiked upward, liquefying the man-made islands in Japan's inland sea off the city of Kobe, spiked upward beyond 7.2 on the Richter scale, spiked upward to throttle the fault line that ran six straight miles from the center of Kobe to the center of Nishinomiya, a city almost equally as large, spiked upward to dump 500,000 buildings flat down, and spiked upward to bounce the house where we were living. Often enough we'd heard the Japanese say of earthquakes, when they are side to side, no problem; but when they are up and down, very big problem, indeed.

I was asleep on a futon in the tatami room downstairs; Laura Ruth was asleep beside me; Alice was already up in the galley kitchen, making a brown sugar and butter frosting for a coffee cake she was about to put in the warming oven. The house, in the sudden, 10,000-jet-engine roar, bounced, lifted and fell back, lifted and fell back, bounced and bounced and bounced as God bullet-dribbled it in a 20-second demonstration that blew away Goose Tatum.

I heard Alice's call above the roar, shouting to Emily and Max upstairs. I hunched over Laura Ruth, aware in the mad torque of the moment that the windows above our futon would have to bulge and splinter soon. And I wondered, and still do, in terror's empty chamber, why does the infinitely-greater-than-Goose God dribble houses, cities?

ABOUT THE AUTHOR—
On Jan. 10, 1994, John Zeugner, professor of history at WPI, moved to Kobe, Japan, with his wife, Alice Valentine, who teaches Japanese literature and culture at Clark University, and their children, Emily, 16, Max, 10, and Laura Ruth, 5. For the next three months he directed, from Japan, WPI's Asian project centers in Bangkok and Hong Kong.

On April 10 he took up his duties as Bryant Drake Guest Professor of Contemporary American History at Kobe College, the third oldest women's college in Japan. His contract with Kobe College called for three semesters of teaching, concluding in July 1995. But six days after the Kobe earthquake, which collapsed 40 percent of the structures at Kobe College, Zeugner and his family were asked to return to the United States, which they did the following day. He wrote Blowing Away Goose Tatum, *which he describes as a "meditation" on his experiences during and after the quake, upon his return to WPI.*

In 1978 Swartzlander enrolled as an undergraduate physics major at Drexel University. Already fascinated by the field of optics, he found inspiration in courses taught by Lorenzo Narducci, an early pioneer in nonlinear optics. A native of Italy, Narducci earned his Ph.D. at the University of Milan and taught physics at WPI for 10 years before joining Drexel in 1976.

In his sophomore year, Swartzlander began work as a co-op student at the Naval Air Development Center (now part of the Naval Air Warfare Center) in Warminster, Penn., just north of Philadelphia. He started out as a research assistant in the Avionics Division and moved on to work in the Remote Sensing Division.

"I worked on nonlinear optics research," he says. "We were taking infrared light and turning it into green light by doubling the frequency—something physicists call second harmonic generation." The quest for efficient blue and green laser light is one of the hot topics in modern optics. Blue and green wavelengths, the shortest in the visible spectrum, are important because they should make it possible to pack more bits onto CD-ROM disks.

After graduating from Drexel, Swartzlander enrolled at Purdue University to begin work on a master's degree in physics. "I attended a department seminar given by Alexander Kaplan, who was a professor of electrical engineering and a renowned Soviet émigré," he says. "Kaplan knows how to make his work sound exciting. He was doing pioneering theoretical research in nonlinear optics, a field that interested me. I found his talk quite interesting and I asked if I could do a Ph.D. with him."

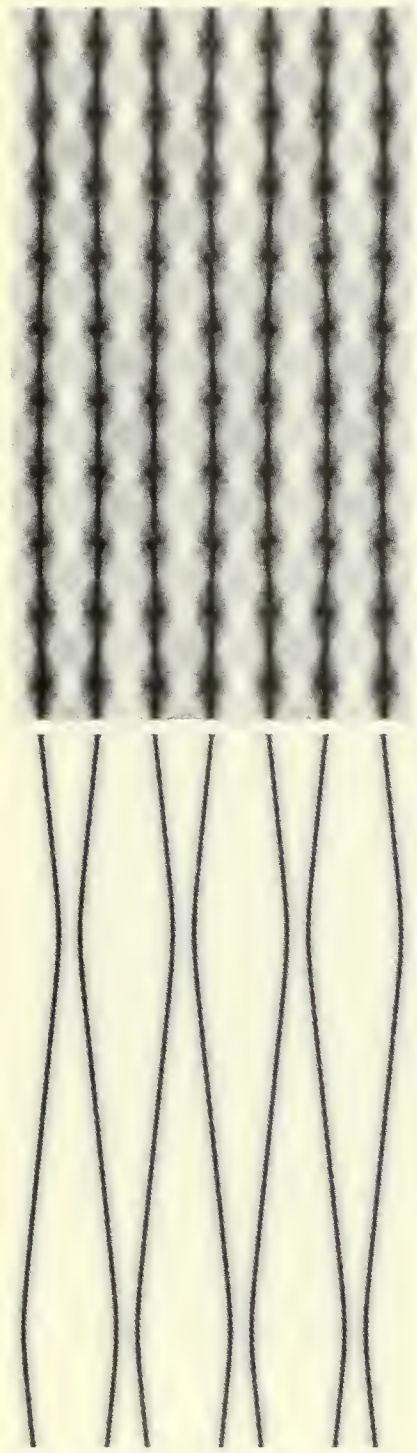
Swartzlander transferred to the Electrical Engineering Department and ended up earning a joint master's in that discipline and physics in 1985. When Kaplan later moved to Johns Hopkins University, Swartzlander followed him and completed the requirements for a doctorate in electrical engineering in 1991.

While working in Kaplan's lab at Purdue, Swartzlander deepened his immersion in nonlinear optics. In physics, the term "nonlinear" is applied to systems in which the output is not proportional to the input—in other words, where the system somehow changes the input in a nonlinear manner. One classic example is the transistor.

A transistor is a sandwich made of three layers of a semiconducting material, such as silicon. The layers are connected to an electrical circuit in such a way that a small current flowing between the first layer and the middle layer induces a much larger current between the middle layer and the third layer. In this way, the transistor amplifies the original current.

Nonlinear effects in optical materials were not observed until the advent of the laser in the 1960s. Suddenly, materials like glass, which was once thought of as a passive transmitter of light, began to exhibit some strange behavior. "One of the first

"Beauty is truly a guide in this work. There are many things in nature that are difficult to understand because they are so complex. But with optics, the way things look provides a clue to what is going on."



Top, a diffraction pattern produced with a fine mesh and a low-intensity light beam. At a higher intensity, a new pattern emerges. As a result of nonlinear effects, refraction is minimized and destructive interference is concentrated into narrow, stable bands. These are called dark soliton stripes. Discovered by Swartzlander, these were the first spatial solitons ever observed.

effects scientists saw was damage," Swartzlander says. "The laser would destroy glass lenses and other transparent materials that seemed to have very little capacity to absorb light."

When scientists began looking for the cause of their fried lenses, they found that the laser light was inducing a localized change in the refractive index of the glass. The skewed refractive index, in turn, caused the beam to focus down, concentrating all of its energy into a tiny section of the lens. "The intensity would get so high it would start ripping electrons off the atoms," Swartzlander says.

Since the narrowing of the light beam was caused by the beam itself, the phenomenon was dubbed the self-focusing effect. As researchers continued to probe such nonlinear behavior, they discovered that other materials can cause light to self-defocus, or rapidly spread out into a diffuse, dim blob. In his work at Purdue, Swartzlander experimented with yet another unusual nonlinear behavior (which Kaplan had predicted): self-bending.

Kaplan had shown that a laser beam with an asymmetrical spatial-intensity profile (in other words, a beam that is more intense at its center than at its edges) will alter the refractive index of a nonlinear material in such a way as to induce a nonlinear prism in the material. Like an ordinary glass prism, the nonlinear prism causes the laser beam to change direction. Since the effect occurs continually along the beam's path, the result is a gradual curving of the beam's course.

Because of limitations in the materials used, the earliest examples of self-bending were observed with pulsed lasers. This made it difficult to determine whether the bending effect could be maintained as a steady state, something that would be critical if the bending were to be used in a practical application. Knowing that sodium vapor has a larger nonlinear effect than most materials, Swartzlander and Kaplan set up an experiment using this gas and became the first researchers to observe a continuous self-bending effect.

One of the most intriguing products of nonlinear optics is the soliton, or solitary wave. Although they were not observed with light until the 1970s, water solitons have been known to exist for more than 150 years. In 1838, while riding his horse beside a barge canal in Scotland, J. Scott Russell noticed that when a canal boat came to an abrupt stop, it pushed a large, solitary mound of water down the canal. Russell followed this lone wave for more than half a mile and was surprised to see that its height and speed remained undiminished.

Six years later, Russell published a report on his observation in a journal of the British Association for the Advancement of Science, becoming the first person to describe a soliton. Exactly a century ago, two Dutch mathematicians, D.J. Korteweg and G. de Vries, published a nonlinear partial differential equation (the KdV equation) that captured the mathematics of waves in shallow waters, an equation that also described the inner workings of solitons.

In water, a soliton occurs when two properties of traveling waves exactly counterbalance one other. The first is the relationship between a wave's speed and its height (tall waves travel faster than squat waves). A wave's speed also depends on its frequency (waves of longer wavelength travel faster than waves of shorter wavelength).

With a tall wave of short wavelength—like the wave created by the canal boat—the two opposing influences on the wave's speed can exactly balance each other and also work against the natural tendency of the wave to dissipate over time. The result is a wave that will travel long distances with no change in speed or height. One extreme example is the "tidal wave," or tsunami.

In 1973 it was predicted that solitons could be produced in an optical fiber if the tendency of a beam of laser light to spread out in a fiber could be counterbalanced by the ability of the beam to increase the fiber's refractive index (a phenomenon physicists call the Kerr nonlinearity).

The first optical solitons were produced with pulses of infrared light. When a pulse of white light is sent into a glass fiber, it tends to disperse in such a way that the longer wavelengths, which travel the fastest, outpace the shorter wavelengths and end up at the front of the pulse. Over time, the frequencies spread out and the pulse dissipates.

At infrared frequencies longer than 1.3 micrometers, things get turned upside down, and shorter wavelengths travel the fastest. Physicists call this phenomenon negative group velocity dispersion. At high intensities, the change in refractive index caused by the Kerr nonlinearity alters the arrangement of the frequencies of the pulse, so that the longer, slower frequencies end up at the front and the shorter, faster frequencies move to the rear, something known as self-phase modulation.

When the negative group velocity dispersion and self-phase modulation are in balance, the pulse will not disperse and instead propagates as a soliton. In fact, solitons can travel for great distances in optical fibers with no change in size or speed. Solitons are also quite stable. Two soliton pulses traveling at different speeds or in different directions can pass through one another and emerge from the collision unchanged.

Because of their robustness, solitons have long been of considerable interest to the telecommunications industry. While they can carry far greater volumes of information than conventional metal wires (and carry it much faster), fiber-optic systems, because they gradually disperse light, require frequent amplification and reshaping. Placing repeaters every 12 to 60 miles along a lengthy fiberoptic cable can be expensive, and the frequent need for amplification (often by electronic, rather than optical devices) limits the amount of data the fibers can carry.

Solitons, on the other hand, can travel for great distances with less need for amplification. In laboratory experiments, soliton pulses have gone well over 3,500 miles with no signal degredation. Currently, Swartzlander says, Bell Laboratories is building a trans-Atlantic fiber cable that will use solitons. The designers are hoping for data rates of 10 gigabits per second, nearly 10 times faster than conventional fiber-optic lines.

The solitons that will speed across the Atlantic are called temporal solitons because they exist in time. But solitons can also exist in space. Spatial solitons can generate patterns discernable by the eye, as Swartzlander discovered in his experiments with the fine mesh and sodium vapor at Purdue.

Intrigued by his results, Swartzlander did some numerical simulations of the system he was using and determined that the regular array of dots he observed was actually a grid of dark solitons. It was the first time anyone had observed a stationary, two-dimensional optical soliton array. "It was thought that such patterns could not exist," Swartzlander says, "because the theory then available could only account for one transverse degree of freedom. We found numerically that we could get regular arrays of these grids and that they were stable. The criterion for stability is important in nonlinear systems; without it, chaos may develop."

Swartzlander says the screen he placed in front of the laser created a two-dimensional diffraction pattern. "If you look through a screen window on a moonlit night, you can see multiple images of the moon—a nice regular pattern—because the screen diffracts the moonlight. That's linear diffraction.

"When you add in nonlinear refraction, you get a counterbalancing between diffraction and refraction. In the process, you create destructive interference that tends to get concentrated in distinct areas. These areas, where the light waves cancel each other out, are the dark solitons."

After receiving his Ph.D. from Johns Hopkins, Swartzlander went to work for the Laser Physics Branch of the Naval Research Laboratory as a postdoctoral fellow. Working with branch head Anthony J. Campillo, another pioneer in nonlinear optics, Swartzlander began exploring whether nonlinear optical effects might become the basis for devices that can protect eyes and delicate optical sensors from direct exposure to high-intensity laser beams. With the advent of laser weapons and the frequent use of lasers in range finders and targeting systems, the potential for such exposure on the battlefield has grown tremendously in recent years.

To further his research, Swartzlander independently applied for and received a two-year, $210,000 grant from the Advanced Research Projects Agency (ARPA). With the funds, he set up some experiments and computer simulations aimed at demonstrating that the nonlinear self-defocusing effect might be just the ticket for creating a practical laser protection device. The idea was to find nonlinear materials that are clear in regular light, so as not to impair normal vision, but that have the ability to instantly react to and defocus laser light, lowering its intensity to harmless levels before it can damage an eye or a sensor.

The underlying goal of the laser-protection project was to find a way to get light away from a region of space. In the process of testing systems that accomplished just that, Swartzlander discovered a new phenomenon that dispatches light in an most unusual manner. Called the optical vortex, it is essentially a light wave that has a spiral phase profile, rather than the sinusoidal or sine wave profile one normally associates with light, sound and water waves.

When light is twisted into this corkscrew shape, something remarkable happens. Through destructive interference, light waves entering the center of a beam made up of optical vortices cancel each other out, leaving a dark core or filament at the heart of the beam. Seen from head on, the beam appears as a bright doughnut of light.

Swartzlander realized that these hollow light beams might do some interesting and potentially useful things when directed into nonlinear materials. He sent them into materials that defocus laser beams—that is, materials that have a high refractive index when exposed to low-intensity light, but that develop a low refractive index when exposed to high-intensity light.

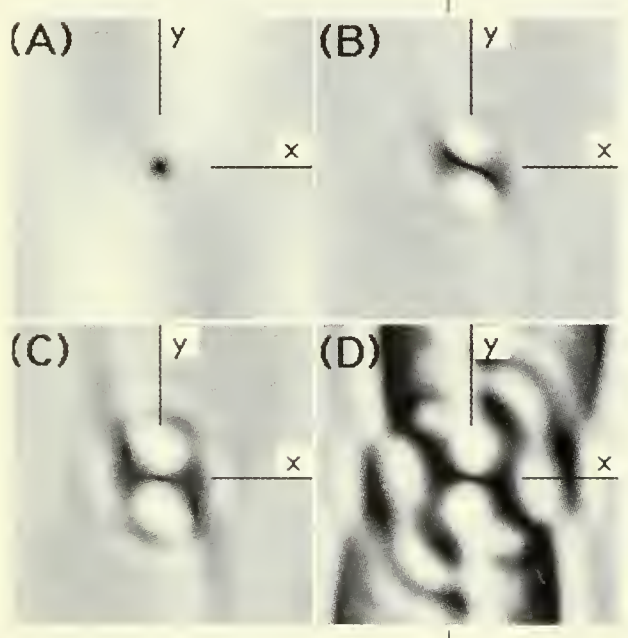
"That means," he says, "that in these materials, the refractive index is actually higher inside the dark core of the beam, where there is, for all intents and purposes, no light, than in the bright, outer part of the beam. The refractive index is what guides light. If you have a region of high refractive index surrounded by a region of low refractive index, what you have, in essence, is a waveguide. This is how optical fibers work."

What Swartzlander had discovered was a way of inducing an optical fiber inside an otherwise uniform material. Experimentally and using computer simulations, he demonstrated that the dark core of an optical vortex shrinks to a constant, unchanging diameter when it passes through a defocusing material. The opposing effects of refraction in the core and diffraction in the light areas result in a stable vortex that is highly resistant to change. It is, in fact, a soliton.

Swartzlander's first report on the optical vortex soliton appeared in the journal *Physical Review Letters* in 1992 and immediately attracted the attention of physicists around the world. In the article, he reported that in experiments at the Naval Research Laboratory, he had been able to introduce a laser

An image of an actual optical vortex soliton. Twisted into a spiral shape and passed through a nonlinear material, a light beam forms a narrow dark region (the dip in the intensity profile graph) that behaves like an optical fiber. These stable fibers can be used to guide other light beams.

Above, Swartzlander with graduate student Xiaoming Zhang. Below, under the right conditions, an optical vortex (A) can become unstable and generate turbulence (B-D). Swartzlander says optical turbulence may produce potentially useful changes in materials.



beam into the dark core of an optical vortex soliton and guide it through a nonlinear material. This ability to control light with light may open the door to some important applications.

One of the most tantalizing is called an optical interconnection. Now in development are new generations of massively parallel computers that will use thousands—and potentially millions—of individual processors to solve complex problems quickly by dividing them into pieces and assigning the pieces to separate processors that work in tandem.

"The interconnections between these processors are potential bottlenecks," Swartzlander says. "You're talking about connecting planes of information with millions of different data channels. If you were to do that electronically, you'd get cross talk as the electric fields of all of those circuits interfered with each other. It's very hard to filter out that much cross talk."

Replacing the wires with optical fibers can eliminate the cross talk, Swartzlander says, though running optical fibers between thousands of processors also represents a major challenge. But if one uses optical vortex solitons, the light will make its own path from one processor to another. In fact, by talking advantage of the unique properties of vortices, it may be possible to continually reroute data through a nonlinear "bus," making and breaking connections between processors as needed.

"When you have two vortices in water, they tend to spiral around one another," Swartzlander says. "They actually produce a force on each other that can change their orientation in space. We want to see if we can do the same thing with two optical vortices. If we can get them to interact with each other, we may be able to start playing some games, creating optical fibers that go where we want them to go.

"You would start with a block of nonlinear material. You would then send two intensity profiles into one end, where they would create interacting dark channels. If you could control the inputs, it should be possible to make the light come out where you want it to. Optical vortices might also be employed in optical logic. With vortices, you have two states—a vortex by itself that stays put, and two vortices that spiral around one another. That's a binary system, and binary systems are what make digital computers possible."

The tantalizing prospects for optical interconnections and optical logic point the way to a brave new world where photons may one day replace electrons in all sorts of computer and communications applications. But to make this photonic world a reality, it may be necessary to create an optical equivalent of the semiconductor, which is the foundation for modern computer technology.

In his experiments with dark solitons, Swartzlander may have found the basis for such an optical semiconductor. "When we think of dark solitons, we tend to think in terms of a small number of them," he says. "But by using mirrors and reflective boundary conditions in the laboratory, we can create what is essentially an infinite number of solitons. The result is very much like a semiconductor. With a semiconductor, you have a periodic array of atoms; here we have a periodic array of solitons.

"In semiconductors, you have bands and gaps—very broad energy levels separated by gaps in the energy spectrum. This notion of band gaps is what revolutionized the semiconductor industry and made possible computer chips. Now we can do something similar in optics using these dark solitons. That may open up opportunities to do what is being called photonic band-gap engineering."

While much of the excitement over solitons has focused on their potential to revolutionize computing and telecommunications, there is another frontier that also intrigues Swartzlander. Using optical vortices, he says, it may be possible to fine-tune the properties of materials. "This is already being done experimentally, but it hasn't yet become a real systems approach," he says. "We know that turbulence changes the state of any system where it exists—it's sort of a fourth or fifth state of nature. If you can produce optical turbulence in a material, you should be able to generate some interesting and potentially useful new properties."

Optical interconnections. Photonic semiconductors. Optically engineered materials. Swartzlander says applications like these may well result from his research, but they are not the main reason he spends late nights in his lab. "I'm not trying to make a device," he says. "So whether or not something like an optical interconnect works is not paramount. What is important is that we explore the frontiers for beauty in physics. The concept of vorticity, for example, has fundamental significance in many areas of physics."

In fact, vortices are at the center of many contemporary areas of the physical sciences, including some of the "grand challenges" of modern science—long-range weather forecasting, wind shear prediction, turbulence and chaos, and superconductivity, for example. "Superconductors exclude the magnetic field and remain in a superconducting state by generating vortices," he says. "There are also superfluids that tend to go up the sides of a glass and try to escape. They produce something called quantum vortices, which are similar to the vortices we're looking at. Vortices are also precursors to turbulence."

To study the relationship between vortices and phenomena like turbulence and superconductivity,

scientists need good models. Water waves are a common system studied, but Swartzlander says optical vortices may provide a better model. "Light waves are the same as any other type of wave," he says. "But since optical systems are very easy to control and observe, they should serve as ideal platforms for experiments involving vortices."

In recent work, Swartzlander and his longtime collaborator, Chiu Thi Law at the University of Wisconsin, have discovered that the classical physics of vortices may link two of his most significant discoveries—dark soliton stripes and optical vortices. "We've found in observations of dark soliton stripes that there is an instability that can be excited in them," he says. "When that happens, the dark solitons break up into vortices. So there appears to be a profound relationship between these two phenomena. People who work in hydrodynamics would especially appreciate this, because it is similar to something they call a flow boundary.

"When you have two layers of moving water passing one another, the interface will remain stable unless there is a small perturbation. Then the interface starts to form rolls and breaks up into vortices. In hydrodynamics this phenomenon was observed as far back as the 19th century. Now in optics, we're just beginning to see it. That's very enjoyable."

With the Young Investigator Award from the NSF, Swartzlander, who joined the WPI faculty in 1993, says he will be able to expand his laboratory and delve further into uncharted domains of physics. With NSF funds and corporate matching gifts and discounts, he has already added a 25-watt argon laser and a new optical table to his store of equipment, and a superminicomputer for crunching numbers may be added soon. (Currently, Swartzlander runs the complex computer models he uses to enhance and guide his laboratory work on computers at the University of Wisconsin, working in collaboration with Law.)

He also hopes to bring more students in as partners in his research. Currently, two Ph.D. candidates, a master's candidate and an undergraduate student work in his lab. Swartzlander has also worked with four undergraduates completing Major Qualifying Projects; two have been co-authors on published papers and one, Dennis Drugan, has presented a paper at a major international meeting.

But most of all, the NSF award will enable Swartzlander to spend more time doing what he enjoys most—watching the dazzling dances light can perform. "Beauty is truly a guide in this work," he says. "There are many things in nature that are difficult to understand because they are so complex. But with optics, the way things look provides a clue to what is going on. You get a gut feeling about whether something is worth looking into. You see something with a certain symmetry and you say, "Aha! That must be something fundamental. It's like nature trying to speak to you."

they scan through graphical displays of the wing sounds and electronically snip and save the best ones. These are then looped into long segments and processed until they exactly match the pattern and modulations of a female mosquito ready to mate.

The mosquito project is but the latest episode in the long and rich history of acoustics research and education at WPI, a history that dates back more than half a century. Over those five decades, three faculty members have directed an educational program that has prepared hundreds of WPI graduates for careers in the fields of audio engineering and acoustics. They've also conducted a wide-ranging research program that has touched on topics as diverse as hearing protection, sound attenuation in spacecraft, and the sound quality of major concert halls. Today, under the direction of Richard Campbell, the program is poised to further expand its scope and capabilities as it makes plans for a new undergraduate project laboratory and a new global project center, both dedicated to audio and acoustical engineering.

PHOTO BY JONATHAN KANNAIR

In the WPI Acoustics Lab, William Michalson, left, and entomologist Sam Martin record the sound of a mosquito as it buzzes around a test chamber.

Campbell traces the origin of the program to Hobart Newell '18, who taught electrical engineering at WPI from 1921 to 1965. Before coming to WPI he helped set up radio station KDKA in Pittsburgh, one of the nation's first commercial broadcasters. He also worked with Edwin Howard Armstrong, the inventor of frequency modulation, and helped Armstrong build the first FM transmitter in New Jersey. In Worcester, Newell helped set up the world's second FM transmitter.

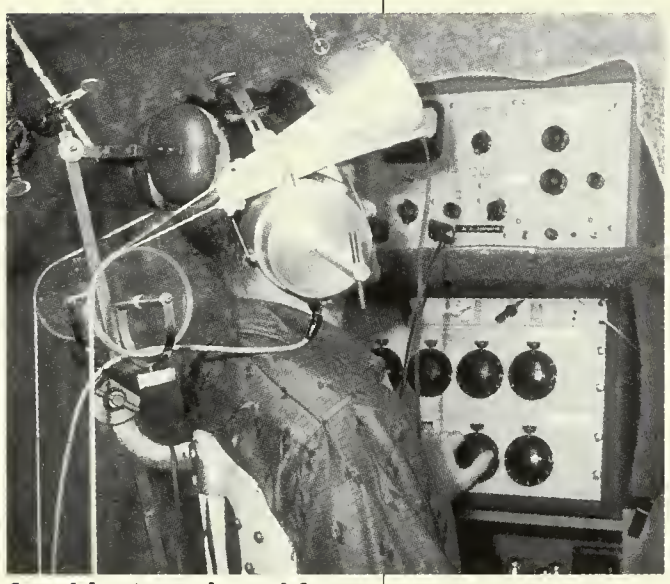
The clarity of the FM signal demanded the development of high-quality loudspeakers, something that intrigued Newell. He and a colleague formed a company to manufacture a high-fidelity speaker. "That was really the beginning of WPI's involvement with audio," Campbell says. To further his research, Newell set up an audio lab in the basement of Atwater Kent Laboratories (named for

another WPI alumnus and radio pioneer) where he built an anechoic chamber, a room where all sounds are absorbed by special material on the walls, ceiling and floor.

The program that Newell started flourished under its second director, William Wadsworth '40, a student of Newell's who earned his bachelor's and master's degrees in electrical engineering at WPI. Growing up in a wealthy family, "Waddy," as he was known to students and colleagues alike, was immersed in classical music as a child and developed a passion for fine music and music reproduction. Like Newell, he was drawn to loudspeakers; he developed a unique graphical approach to solving electrical problems, largely to tackle the complex feedback problems associated with speaker design.

Throughout his 43 years as an instructor, Wadsworth taught students to solve problems through the use of his "Waddygrams," even after sophisticated electronic calculators made most graphical analysis systems historical curiosities. "Waddy believed that an engineer should be able to solve a problem on a mountaintop with pencil, paper and a straightedge," Campbell says.

In the early 1950s, Newell moved from his spacious house on West Street and donated it to the Institute. It promptly became the new Acoustics Laboratory. The lab returned briefly to Atwater Kent in 1964, when the Newell House was razed to make way for Goddard Hall, and then found a new home in the three-story unit operations lab in Salisbury Laboratories, left vacant when the Chemical Engineering Department moved into Goddard.



A subject equipped for a test of Wadsworth's hearing protectors. The head gear kept the head properly aligned and a "bone driver" securely pressed against the subject's forehead.

During those years the lab acquired a Mauler Reverberant Chamber from Raytheon Co., which had used the steel-walled room and its three huge speakers to rattle air-to-air missiles with simulated jet engine noise. The growing space demands of the biology and biomedical engineering programs forced a final move for the Acoustics Lab in the mid-1970s, this time to the Higgins House garage.

In 1952 the Acoustics Lab received a challenge that would occupy Wadsworth and a small phalanx of undergraduates and graduate students for the good part of a decade. The gauntlet was thrown down by the David Clark Co. in Worcester, famous then for the anti-G suits it was making for military jet pilots (the company would go on to make pressure suits for every manned U.S. space endeavor). David Clark had been asked by the U.S. Air Force and Navy to find a way to protect the hearing of airmen and sailors who work near the ear-shattering roar of jet engines. Not knowing where to begin, the company came to Wadsworth.

"It was impossible to work on the flight line or on a carrier deck without realizing that you were in a very unhealthy place," Campbell says. "Any medical man or woman of the day, or any commanding officer, would have paid anything for a solution."

Wadsworth developed a basic plan for a muff-type hearing protector that consisted of a hard fiberglass shell lined with plastic foam, sponge and chamois. He also designed and built an equivalent electric circuit that substituted resistors, capacitors and inductors for these materials. The circuit enabled the design to be fine-tuned and tested without the need to constantly fabricate new earmuffs.

A number of protocols were devised to test the prototype protectors. The experimental work was funded by yearly grants of $10,000 to $12,000 from David Clark. Campbell, who joined the lab as a research assistant in 1957, served as a test subject in many of these experiments.

For one of the tests, the subject sat in a converted dentist chair inside the anechoic chamber with his head resting in a cradle to keep it pointed in the right direction. The hearing protectors covered his ears and a "bone driver" (a speaker that delivered sound directly to the bones in the head) was fastened to his forehead. Over all this was placed a shell resembling an ancient diver's helmet (see photo, page 12), which enabled very loud sounds to be delivered directly to the subject's head.

The test, called the pure-tone loudness-balance method, enabled Wadsworth to compensate for the occluded ear effect, in which covering or partially blocking the ears artificially reduces a subject's ability to detect the threshold level for a sound. It worked well, Campbell says, "but what a price we paid! You could tell an Acoustics Lab staff member by the red impression in the center of his forehead caused by wearing the bone driver for hours on end."

Hundreds of hours of tests and dozens of modifications of the muff design produced a hearing protector that suited the needs of the Navy and Air Force. It also earned a patent for David Clark, although it would take six years for the application to win approval. Says Campbell, "Waddy made the mistake of calling the device an ear protector, so the Patent Office sent it to the wearing apparel division. Those poor patent examiners!"

On the decks of carriers, the hearing protectors worked so well they made it impossible for sailors to talk to each other. The Navy came back to Wadsworth and asked him to come up with a way for carrier deck personnel to communicate—one that would not permit any radio signals to travel beyond the confines of the ship, where they might be intercepted by the enemy.

"The transistor had been invented just a few years earlier, so there was no miniaturization—and nothing ran on batteries," Campbell says. "We built

small FM receivers into the hearing protectors, using some of the 12 or so transistors then on the market. We ran thick cables around the perimeter of the deck and sent about 100 amperes of audio through them. The signals reached the receivers through inductive coupling. We also designed a special antenna that provided good reception no matter which way the head was oriented."

Campbell earned his undergraduate degree in electrical engineering at WPI in 1958 and stayed on for two years as a graduate student, working all the while as a research assistant in the Acoustics Lab. In 1960 he decided the time was right to launch his own career as an acoustical consultant. For more than a decade he did most of his consulting for the David Clark Co. and the WPI Acoustics Lab. Much of that work was tied to the tremendous demand for new technology generated by the rapidly evolving U.S. space program.

Campbell's introduction to aerospace research came while he was still a graduate student. In the late 1950s NASA began flying the X-15, the sleek, black rocketplane built to test the performance of aircraft at extremely high speeds and altitudes. David Clark built the pressure suits for the X-15 pilots, including the suit communications systems. The company asked Campbell and Wadsworth to improve the performance of the pilot's microphone.

During the project, Wadsworth was offered the chance to measure the noise generated by the X-15's powerful liquid-fueled engine. "He brought the best experimental hearing protectors we had," Campbell says, "including a supra-aural model made from glass jelly jars (glass is the perfect material for a hearing protector shell)."

Wadsworth stood about 150 feet from the rocket during a test firing. "He nearly collapsed from the enormous sound pressure on his body, his measuring instruments failed, and he turned and ran away from the sound," Campbell says. "Though shaken, he was quite pleased with the performance of his experimental design."

Campbell, as a consultant to David Clark, went on to design the electronics and communications systems for the Gemini space suit. Because of the exceedingly high noise produced by the Titan rocket that would lift the Gemini spacecraft into orbit, NASA was concerned that noise inside the capsule would prevent the two astronauts from hearing voice communications during launch.

David Clark and the WPI Acoustics Lab agreed to measure the ability of the Gemini suit to attenuate sound. The measurements would enable the researchers to predict the ability of the astronauts to hear and be heard. "I worked 16-hour days for a week to rebuild the anechoic chamber in Atwater Kent, replacing the sound-absorbing material, which was falling apart, upgrading the lighting, and preparing the room for all of the wires and tubes we would have to run in to support the suit.

"It looked like Launch Control just outside the sound room door, as we juggled gas valves, signal settings, ventilation pipes and what all. Waddy himself insisted on being one of the subjects. In the end we got really good data and showed the gang in Houston that if their predictions about sound pressure in the cabin were correct, there would be acceptable communication—and there was."

By 1963, when early design work for the Apollo spacecraft began, Campbell was spending most of his time working for David Clark. He did much of the design work for the electrical systems in the sophisticated new flight suit Clark designed for the Apollo astronauts. Another firm was designing the communications gear for the "Snoopy hat" the astronauts would wear in the capsule, and North American Aviation was doing the communications system for the command module, itself.

"There were some problems with this equipment," Campbell says. "After I made a few visits to North American's Downey, Calif., plant, where the command module was being assembled, I approached NASA and told them the equipment being put into the spacecraft wasn't going to work. They were in for some nasty surprises."

David Clark had already developed a successful communications system for pressure suits used in the huge chambers where the Apollo spacecraft was tested in a simulated space environment. "As a result of that success, we got the contract to do the communications for the Block 1 spacecraft, which was intended solely for Earth orbital test flights," Campbell says.

"There were a lot of things in that capsule that made my job difficult, including a new computer that produced a lot of electrical noise, and it took a great deal of work to get everything to work right. I remember delivering some newly potted headsets to Downey one weekend and then spending half a day in the spacecraft hooking up wires and trying to trace down a noise. That was AS 204, the one that burned three months later."

The fire in Apollo 1, during a launch rehearsal in 1967, an accident that killed astronauts Virgil "Gus" Grissom, Edward White and Roger Chaffee, was devastating to everyone who had worked on Apollo, Campbell says. Later, as work on the design of the Apollo hardware came to a close and the program moved forward to send 27 men to the moon and back, Campbell says "a period of postpartum depression" set in for those who had been heavily involved with the design work. "There's only one project like that in a lifetime," he says.

Campbell, sometimes in collaboration with the WPI Acoustics Lab, continued to design electronics for space projects. He also designed large and complicated intercom systems for manufacturing plants where huge airplanes like the C5 and the B1 Bomber were built, as well as communications systems for the National Football League. For the Navy's Sealab project, he designed the first carbon

A Titan rocket lifts a Gemini spacecraft off the launch pad. Tests by the Acoustics Lab proved that the noise from the rocket would not prevent astronauts from hearing voice communications.

dioxide scrubber capable of diving to 1,200 feet. And he had time to design "the world's most popular aviation noise-attenuating headset, still manufactured by David Clark," he says.

"The headset is the most instantly recognizable piece of audio equipment in history," Campbell says, "as it appears in nearly every motion picture and television show where a helicopter is involved. Occasionally I will hear the clean output of my old noise-cancelling boom microphone over the broadcast channel with great satisfaction."

"The best acoustical instruments in existence are the human ears and the human brain. I'm certain that 100 years from now, people will be saying exactly the same thing."

In 1972 Campbell bought some property in Woods Hole, Mass., and began a second career as a boat yard owner. He continued his interest in audio electronics and acoustics, though, designing intercom systems for television studios and power plants (he also designed the communications system that CBS Television News used in its broadcasts from the floor of the 1976 presidential conventions).

A few years later he wrote a white paper for the Audio Engineering Society of America on the need for international standardization in audio equipment and testing procedures. As a result, the AES formed a standards committee, on which Campbell served. "The AES Standards Committee now covers virtually everything in audio engineering," he says. Campbell's white paper earned him a fellowship in the AES. He is also a fellow of the Foundation Les Treilles in France and has twice received the Citation of Outstanding Service from the Radio Technical Commission.

Throughout this period, he remained in close touch with the WPI Acoustics Lab, and from 1964 to 1974 he was an invited lecturer in acoustics and audio engineering at WPI. By 1981, Waddy Wadsworth was ready to retire. "He said to me, 'There's nobody to teach acoustics. Why don't you do it," Campbell says. "I thought it was a neat idea. Waddy and I taught the course together in 1981, and I've been teaching it ever since."

Wadsworth was still teaching students his "Waddygrams" and he hadn't changed the content of the course much over the years, even as the switch to seven-week terms in the early 1970s changed the demands on classroom instructors at WPI, Campbell recalls. "The students were coming out of class with their eyes glazed over," he says.

Campbell set to work to revamp the course, building a detailed study of acoustical principals and audio electronics around the premise of creating a public address system for a specific hall. "We have a few components—a human, a microphone, a loudspeaker, an audience and an auditorium—and we analyze every bit of that to within a gnat's eyebrow," he says. "In the process, the students come to learn a lot about engineering."

Students delve into a broad range of topics, from how speech works, to employing band-pass filters, to the principles of digital signal processing, to architectural acoustics, to transducers and loudspeakers. Along the way they measure the acoustics of a large church, learn about sound from the point of view of a musical performer, and visit Worcester's Mechanics Hall, including its state-of-the-art digital recording studio.

"Students take this course because they have an abiding interest in audio," Campbell says. "Most of them play music. They all have hi-fi equipment. Many have an interest in pursuing this kind of work as a career." Serious-minded juniors and seniors may also take an extensive, two-term course in electroacoustics offered by the Bose Institute, an educational effort of Bose Corp., a manufacturer of loudspeakers and other audio equipment. For the past three years, Bose has opened its course to WPI students at no charge and has even provided vans to transport the students to the company's Framingham, Mass., headquarters.

Undergraduates with an interest in audio also frequently choose Major Qualifying Projects in acoustics. Campbell and other professors in the Electrical and Computer Engineering Department serve as advisors to these projects, which in recent years have included the design of lightweight loudspeakers for outdoor concerts, an acoustical model of WPI's Alden Memorial, and a portable 16-bit audio sampler for musicians. The advisor for the audio sampler group was William Michalson, whose research interests include satellite navigation using the Global Positioning System, real-time embedded computer architecture, and system simulation and modeling. In recent years Michalson has also become active in the work of the acoustics program.

Students completing such projects have access to the facilities of the Acoustics Lab, as well as to a high-end PC in Atwater Kent equipped with digital sound editing and acoustical engineering software. But this equipment is not sufficient to meet the needs of interested students, Campbell says. With Michalson and Frederick W. Bianchi, associate professor of music and director of WPI's computer music program, he would like to create a laboratory dedicated to acoustics and audio projects. To that end they have laid the groundwork for LAM³, the Laboratory for Acoustics, Music and Multimedia.

The new lab will have at least six IBM-compatible PCs and at least one high-end Macintosh computer. There will also be keyboards, equipment to hook electronic musical instruments to computers, loudspeakers, amplifiers, portable digital tape recorders, and networking hardware. A $25,000 bequest from Professor Wadsworth, who died in 1993, was the first of several major gifts needed to make the lab a reality.

Developing in parallel with the new laboratory is an international project center dedicated primarily to student projects in musical acoustics. Campbell says he and others at WPI are currently working with officials at the Institut de Recherche et Coordination Acoustique/Musique (IRCAM), part

of the Pompidou Center in Paris, which Campbell calls the "center of gravity of research in music and acoustics," to establish a program that will enable students to spend seven weeks at a stretch conducting MQPs and Interactive Qualifying Projects with IRCAM faculty members.

One of the primary areas of research at IRCAM is concert hall acoustics—in particular, how the acoustics of concert halls affects the ability of musicians to perform, a subject Campbell says has long been neglected by acousticians and architects alike. "You can't make good music in a bad space—it's just not possible," he says. To understand what audiences and performers hear during a concert it is necessary to make detailed acoustical studies of performing spaces.

Using binaural microphones that simulate the human ears and specially designed speaker arrays, acousticians send bursts of sound into a hall and then record the reverberating sound at several points around the auditorium. In a well-designed hall, the reverberations die out smoothly in about two seconds. In addition, there are no architectural features that cause sound to reflect unpredictably or to get lost.

To accurately chart the acoustics of a hall, one must do measurements while it is empty and while it is full of people, for the presence of an audience greatly affects the reverberation decay rate—generally for the better. Over the years such measurements have been made in a number of major concert halls, but Campbell says a lack of uniformity in the measurement techniques and equipment used has made analyzing the data and comparing halls difficult.

That lack of uniformity was the motivation for the creation in 1990 of the Concert Hall Research Group, founded by Leo Beranek of the renowned acoustical consulting firm Bolt Beranek & Newman. With funding from the Acoustical Society of America and several private organizations and corporations, the group has begun to compile a database of concert hall measurements. So far, several halls in Europe and 11 auditoriums in the U.S. and Canada have been recorded.

Campbell, a contributor to the group, maintains a public collection of acoustical data gathered by the Concert Hall Research Group on the Internet (ftp://ee.wpi.edu/acoustics/) and plans to make the huge store of data available on a CD ROM disk in the future. He also supervised the sampling done in Worcester's Mechanics Hall in 1993 and the Portland (Maine) City Hall Auditorium in 1994. This and other data is already playing an important role in one of the most active and critically important areas of modern acoustics, the computer modeling of auditorium acoustics.

Good computer models should enable acousticians to predict the acoustical quality of a hall before it is constructed, preventing costly mistakes, such as the much publicized first version of Philharmonic Hall (later renamed Avery Fisher Hall) in New York City. The original hall's acoustical deadness was lambasted by critics, audiences and musicians when it opened in 1962. Ultimately, the hall was completely rebuilt.

The best existing computer models are still no match for the experience and judgement of the best acoustical engineers, Campbell says, but they are getting better all the time. Having complete and consistent data from major concert halls will enable the models to be validated and improved. Currently, Campbell is testing a model of the Portland auditorium developed by an acoustical consultant to see if it can help explain an unusual feature of the hall.

PHOTOS BY JONATHAN KANNAIR

Top, Campbell explains the acoustics of Trinity Lutheran Church in Worcester to students in his acoustics course. Bottom, Campbell and Theodore Woehnker '95, in the balcony of the church, examine the speaker array used to test the acoustics of indoor spaces.

"In our measurements we found a seat in the third row of the second balcony that has a big anomaly," he says. "You would think a seat is a seat is a seat, but this seat is different. It has a funny reflection coming from the stage, and another one coming from a wall on the right-hand side. We can see this as clear as a bell in the data, but does the model see it? So far, it looks pretty good."

What is interesting, Campbell says, is that the area around the anomalous seat is where everyone wants to sit. "Whatever the anomaly is, people like it," he says. "That just goes to show you that the best acoustical instruments in existence are the human ears and the human brain. I'm certain that 100 years from now, people will be saying exactly the same thing.

"There is so much to human perception, and so much we simply don't understand. It's not just the nuts and bolts of frequencies and reverberation times. There are also things like emotion and creativity. That's what makes this field so much fun."

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Swimming Against the Odds

PHOTOS BY DAVID CARSON. USED BY PERMISSION OF WORCESTER TELEGRAM AND GAZETTE

Congenital abnormalities left Jason Wening '97 with legs amputated below the knee. But with raw talent and equal measures of courage and determination, he has become a world-renowned swimmer.

BY JOHN GEARAN

He slips out of his artificial legs as if they were a comfortable pair of old slippers, resting them against a bench. He slides across the tile floor of the pool's apron, handpresses himself onto the elevated starting blocks, and sets himself square on his knees. The race has not yet begun, but Jason Wening '97 knows he is already well behind.

In a sport measured in fractions of seconds, Wening will hit the water at the feet of fellow competitors in adjacent lanes, behind from the start by at least a full body length. On his knees he is decidedly shorter than his competitors and unable to propel himself from the blocks. When he surfaces he will be trailing them by about 10 feet. He knows that at every turn he will lose another half a body length because he has no lower legs to push off the pool wall as other swimmers flip and explode in the opposite direction.

He knows there are 39 turns in his specialty, the 1,000-yard freestyle. You do not need to be an applied mathematics major—which Wening happens to be—to figure out that he is losing 1.5 lengths at the start and a half-length at each of the 39 turns. That means Wening must make up 21 body lengths (or 126 feet for a six-footer) just to get even. That equals 42 yards, almost two lengths of a regulation 25-yard pool.

What is far easier to calculate is that Wening—4-foot-6 without his artificial legs—competes against his peers at a distinct disadvantage. Nonetheless, Wening does not whine about uneven playing fields or anything else. Instead he swims hard and sometimes wins. Without lower legs with which to make a final kick to victory, with a deformed left hand, structural problems in his hips and thighs, and no feet, Wening goes all out against all odds.

Among other handicapped athletes, Wening is a world record holder and gold medal winner. In the fall of 1994, while captain of the U.S. Swim Team, he brought home one gold and two bronze medals from the World Championships for Disabled Swimmers in Malta. During the 1992 World Disabled Games in Barcelona, Wening set three world records while capturing gold medals in the 400-meter and 200-meter individual medley (breaststroke, backstroke, butterfly and freestyle).

Against collegiate competition, Wening is flat-out good. "Currently, Jason is the second best on the team," says WPI swimming coach Whit Griffith. "We make no exceptions for him. He received a varsity letter as a freshman and earned all his points. He's an outstanding person and an outstanding swimmer."

Indeed, Wening is WPI's top swimmer in his two best events: the 500-yard and 1,000-yard freestyles. Everywhere he races he draws cheers from appreciative crowds, whether he's winning the 1,000 freestyle in a time of 11:49.88 against Wheaton or finishing second against Connecticut College in a time of 11:49.91. Think back to that 21-length handicap, and then contemplate the three-hundredths of a second difference between his first- and second-place finishes.

What would Wening's time be without the birth defects that have left him "a bilateral, below-knee amputee," as he casually describes himself? Wening doesn't approach swimming or life from that point of view. He says he accepts what is.

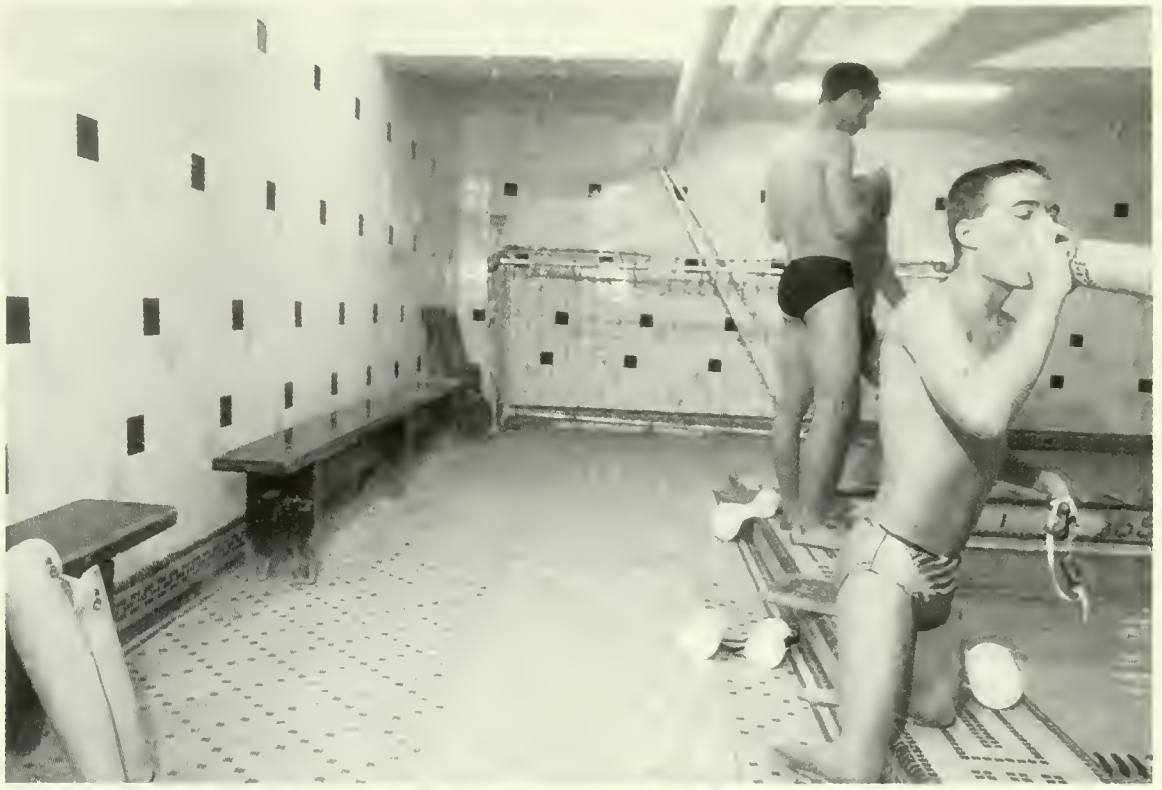
"Long ago I made that mental leap on my own," he says. "I asked myself all the questions: 'What's going on here? Why am I different? What freak of nature caused me not to have legs?' I really did fight that one for a long time. You never really get over it because it's a constant learning experience."

Matter-of-factly he discloses how he was born deformed for no known medical reason. "My mother wasn't taking any drugs, prescription or otherwise, during her pregnancy. Doctors have no explanation. My parents consulted genetic specialists and nobody has any idea where I came from," he explains with a disarming smile.

In 1974 Wening was born with abnormal or missing parts. Lower leg bones were not there. "On my legs I had sort of two toes pointed down and no ankle. Since I couldn't walk on them, they had to amputate (the toes) to make my legs accessible to prostheses."

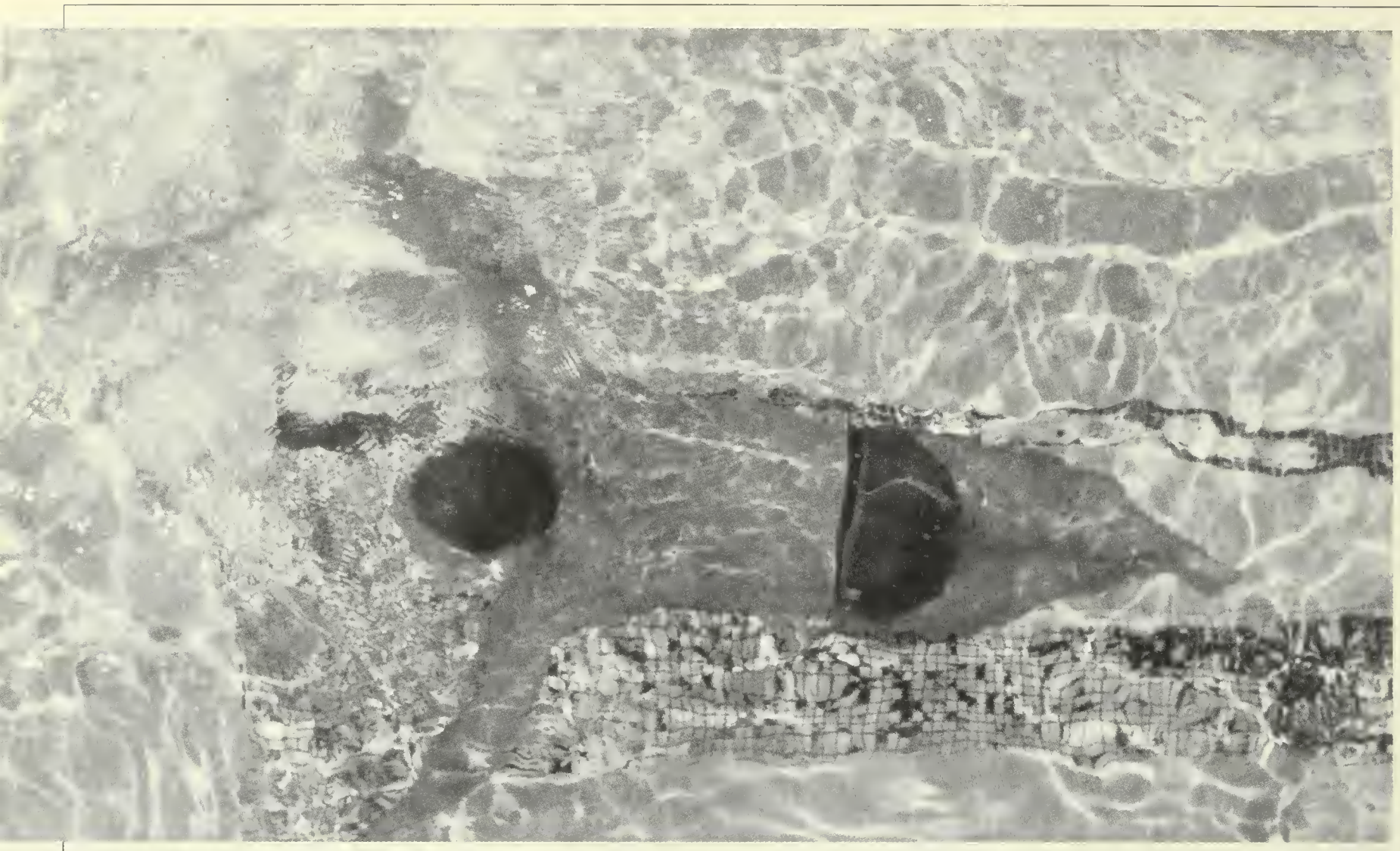
When he was 3 years old, surgeons trimmed his legs below his knees. What Wening remembers about the operation and his hospital stay is indicative of his positive outlook and upbeat attitude. "I recall my grandmother painting Winnie the Pooh on one of my leg casts," he says.

Physical adjustments soon became secondary to psychological challenges. He had to overcome the stares of other youngsters and that nagging inner question of why. His parents, retired Lt. Col. John Wening and Charlotte Wening of Jefferson City, Mo., were supportive, as was the military enclave that surrounded him much of the time. His parents brought him for swimming lessons in the third grade. "But they couldn't force-feed me the answers. I had to draw my own conclusions," he says.



Wening, seen at poolside and in the locker room, leaves behind his prosthetic legs when he enters the water. Despite his physical disadvantage, he is WPI's second best swimmer, a tribute to his fierce competitiveness.

Entering the ninth grade in O'Fallon, Ill., Wening had come to terms with his disabilities. "But in a sense you really never do, because something can always pop up." In a military family, there would be relocations, new friends to make, new cliques to encounter, more explanations to give. And he had to keep pace with his younger brothers, Brian and Gregory.



Between the ninth and 10th grades, swimming became a passion and provided him with personal goals. He had competed against his friends on the Seahawks Swim Team and done OK. When he discovered competition for the disabled, Wening realized that he was not so slow and had more talent than he had thought. His self-esteem and confidence blossomed.

During his junior and senior years, he attended Patch American High, a Department of Defense system school in Stuttgart, Germany. He became a prize student-athlete, winning All-Europe honors for his swimming achievements. He chose WPI for its academic reputation and because he thought he could compete at the Division III level.

Though he starts from his knees, thus far he has finished with his head high. Though he knows he will often be second best or lower, he has not become discouraged—even in an arduous and demanding sport like swimming. "It's not demoralizing to lose, because I learned a long time ago there were some swimmers I would never catch," he says. "I learned to swim my own race. As long as I'm beating my own time, I'm happy."

This is the philosophy he spreads as the captain of the U.S. Disabled Swim Team and when he hollers encouragement as coxswain of WPI's women's crew team. "I tell them as long as you do your best and lose, you can't be disappointed with yourself."

He is remarkably consistent and has unusual endurance. "My disabled team coach once said he loves to watch me 'go fishing.' He calls it fishing because when I leave the blocks, I'm behind everyone and oftentimes I just reel them back in. I really can't swim 50-yard races because I don't have the time to make it up. But in the 1,000, I have enough time."

"When I leave the blocks, I'm behind everyone and oftentimes I just reel them back in....in the 1,000 I have enough time."

When Wening talks about swimming, the little devil dances in his eyes. Clearly he welcomes the challenge he faces in the pool. He also has a marvelous sense of humor. "Swimming is my drug of choice," he quips, only half-kidding. Recently, when Griffith had the team play "follow-the-leader," he ordered Wening's teammates to start off the diving blocks from a kneeling position, as Jason just had done. Down at the other end of the pool, Wening looked back and yelled, "You've got to be kidding, Coach. What is this, Disabled Awareness Day?" When asked for his height on information forms, Wening will sometimes write, "4 feet 6 inches and 5 feet 8 inches with legs."

But mostly he is serious about swimming. Nobody outworks him, Griffith says, and nobody stays in better shape. He has tremendous stamina and discipline, even designing his own more demanding workout schedules. He has simple needs and reachable goals. He wants to make a good enough time to qualify him for the New England regional meet. He wants to lower his world records for disabled athletes. And now that he's stopped growing, he'd like to buy better high-tech legs to replace the relatively cheap pair he's worn daily for almost three years.

Wening knows there will always be curious stares and that some questions will never be answered. "But I've matured enough now that I can look ahead and see a time when I'm married and have kids and have to explain to my kids why their father doesn't have legs," he says.

"And what will you tell your kids?" Wening is asked solemnly. Without hesitation, he quips, "I figure I'll wing that one when the time comes." As we've said, it's hard to stay ahead of Jason Wening.

—*Gearan is a columnist for the* Worcester Telegram and Gazette.

Brewing Success

The Story of Wachusett Brewing Co.

By Joan Killough-Miller

At 26, Edward "Ned" LaFortune III is a happy man. Even after the first blizzard of the new year, with a forklift stranded on the ice outside his brewery, with the temperature inside almost below freezing ("We can step into the cooler to warm up," he jokes), and with nary a drop of bottled beer to offer a visitor, the president of Wachusett Brewing Co. seems relaxed, even pleased, with how things are going. As his two partners struggle to tow the forklift back into the converted garage at Westminster Place, his father drops by with the mail. "My father went into shock when I first told him I was going to open a brewery. Now he works for me," says the younger LaFortune.

Only six years ago, all three WBC owners were sitting behind student desks at WPI, wondering what they would do with their lives. "I figured I would start my own business someday," says LaFortune, "but I thought I would be doing something more along the lines of what we were doing down in Kaven Hall." When he graduated in 1990 with a degree in civil engineering, LaFortune found a job as a project engineer with Camp Dresser & McKee. His friends Kevin Buckler and Peter Quinn had graduated the year before and were already working at General Dynamics and Advanced Environmental Technology Corp., respectively. LaFortune and Buckler both started making beer at home as a hobby, and soon found themselves engaged in a friendly competition for the ultimate brew. They experimented with different hops and yeasts, honing their skills on store-bought malt extracts, then advancing to more elaborate concoctions based on hand-ground grains.

PHOTOS BY JOHN FERRARONE

Peter Quinn inspects the mash wort for a new batch of ale.

As they visited with microbrewers around New England and their chats became more and more technical, it dawned on them that with their engineering background, they could build their own brewery. The two friends knew they would need someone with biology and chemistry expertise, and they turned to Pete Quinn. Quinn had resisted the home brewing bug all along, arguing that if he started, he would get too involved. It took six months to convince him that their dream could be a viable business.

"Our goal is to be the predominant brewery of Worcester County."

Next came an apprenticeship at Ipswich Brewing Co., where they spent weekends learning the trade firsthand while continuing in their engineering jobs. "We did everything, from brewing and mashing in, to cleaning floors and filling bottles," LaFortune says. By the end of 1992, they were ready to begin building their brewing apparatus from salvaged equipment: a thousand-gallon stainless steel dairy vat became a fermenter; two tanks from a pharmaceutical manufacturer were converted to a hot water heater and a brew kettle; and an industrial-size pressure cooker is used to mix grain with hot water to make the mash.

Business plan in hand, the three brewmeisters incorporated in August 1993 and sought financing from family, friends and fans of their home brew. LaFortune says outside financing might have been an option, because venture capitalists are intrigued by the brewing industry and New England microbreweries have a success rate of 90 percent or better. But the trio was committed to designing and

building their own brewery, no matter how unconventional. They wanted to be independent of the terms and repayment costs of outside financiers. In December 1994 they did borrow some capital from a commercial bank to begin operations and finance a Phase II expansion.

Part of their financial strategy was to keep risk at a minimum by paying off their personal debts and keeping their lifestyles simple. All three are single, and their standard of living hasn't changed much since they were students. "I own a pick-up truck, a mountain bike and a snow board," says LaFortune. "That's all they can come get from me." WBC's market research was simple and direct. An intern from Fitchburg State College compiled a database of all establishments with liquor licenses, both container sales and pouring. The partners then called each one to ask what microbrews were being sold, and were able to narrow down the database to a list of likely prospects. LaFortune visited with samples, simply asking the owner to take home a bottle and try the ale.

In September 1994 he dropped a bombshell at CDM, where he was still a full-time employee, by resigning and revealing that he had been president of his own company for more than a year, albeit without drawing salary. Buckler and Quinn followed suit. Although their original plan was to keep their engineering jobs and brew after hours in 10-barrel runs, they made a last-minute decision to go for broke. Buckler found a way to reconfigure the brewing apparatus to double its capacity. This allowed them to market the ale to liquor stores in half-gallon glass jugs called "growlers," as well as to bars by the half-keg. Suddenly, they were all self-employed.

Chemical engineering Professor Robert Thompson, a dedicated home brewer, visited WBC in October 1994, during the final days before start-up. "There were pipes all over the floor, and lumber being cut. No tank was connected to any other tank. But they swore they were going to start brewing in a week—and they did!"

"It was a living MQP," says LaFortune of the 18-hour days that preceded the start of production. "We worked around the clock for a month and even ate off a Coleman stove at the brewery. It was the wisest thing we ever did." The trio got out the first batch of Wachusett Country Ale just a week before Christmas, and it has been a sell-out ever since.

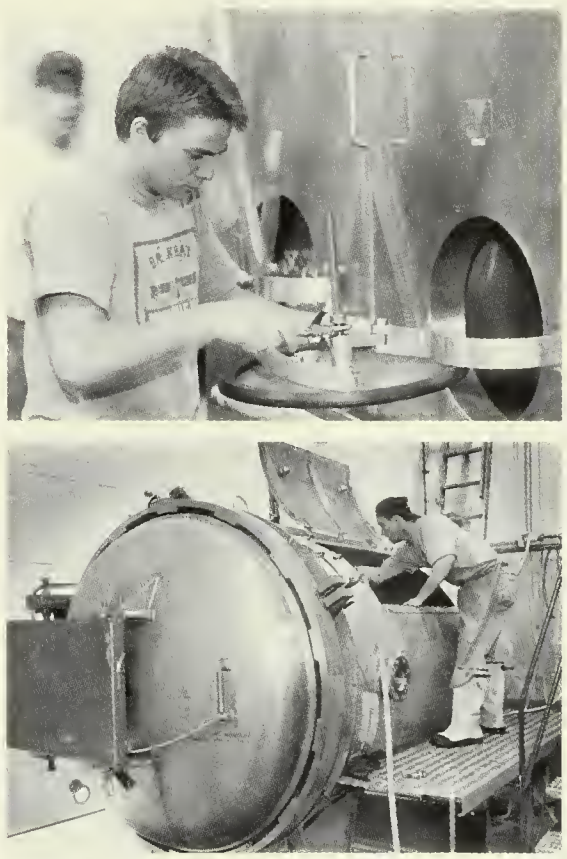
Wachusett Country Ale is best described as a "blonde" ale, says LaFortune—pale in color, with medium body and a creamy texture. The flavor is well-balanced, with its bitterness offset by sweetness. The intent was to create a brew that would appeal to anyone who likes beer. "It's not bitter, not overly hoppy, and it pleases a wide variety of palates—including ours!

"Dark color sets people off," he continues, observing that a lot of beer drinkers are convinced that they don't like dark beers. "They say they want beer that is pale, very carbonated—what the industry makes you think beer is." Unlike mass-produced beers, WBC's ales are unfiltered, giving them a fresh, distinct flavor.

The second product off the line is Wachusett IPA, an India pale ale (a bitter, aromatic style of beer that LaFortune describes as "highly hopped")."This beer is designed for drinkers looking for something a little more aggressive," he says. The name for the new brew, which recently went on sale, reflects the growing name recognition WBC's products are earning. The WBC team plans to stick with ales (their personal favorites) for the next few years. The ale family has many varieties, from porter and stout to wheat blends. They hope to offer specialty seasonal brews as well, and might branch out to lagers, if they can acquire the appropriate tanks.

As small business owners, the three partners have naturally assumed the roles best suited to their undergraduate backgrounds, although there is considerable crossover. LaFortune, the civil engineer, manages the business, but also sells, promotes and delivers the ale. He makes a point of being on hand when bar owners tap their kegs and draw the first draft.

Buckler, a mechanical engineer, purchases and designs the brewing apparatus. His resourceful innovations have saved the company tens of thousands of dollars over the cost of new equipment. Buckler works closely with several contractors who handle technical operations such as welding and electrical, plumbing and refrigeration work.



Top, Wachusett Brewing Co. employee James Krauss prepares the fermenter to receive the wort. Bottom, head brewer Quinn checks the pH of the mash in the mash "tun" (see "Brewing by the Numbers," opposite).

Quinn, the biologist, serves as head brewer, designing all WBC products and ordering the raw materials. He is the only one allowed in the sanitary fermentation room, and he operates an on-site laboratory with extensive quality-control procedures. WBC's brewing process is time-consuming and labor intensive (see table, next page), involving many transfers from tank to tank, with the tanks being sanitized at each step. LaFortune says it's worth the effort to create a beer with a good, clear flavor. "As long as Pete's mind is involved with yeast, he's all fired up," he remarks. Quinn is also responsible for the biweekly federal and state reports and tax payments.

To keep up with customer demand, WBC purchased the contents of a defunct New Hampshire winery and used the equipment to boost their original 20-barrel-a-week capacity to 75 barrels—almost quadrupling their output less than four months after the brewery opened. Wachusett Country Ale is the second best selling beer at Wachusett Mountain Ski Area in Princeton, Mass. (WBC's largest customer), and it has been popular at O'Connors Restaurant & Bar in Worcester and at the Boynton near the WPI campus. The resealable growlers, despite their unconventional appearance, disappear quickly from store shelves.

Neil Coleman, assistant manager of Austin Liquor Co. in Worcester, says the ale is popular with home brewers and beer drinkers who might not have initially considered a microbrew. "Because it's local, people try it on a whim. The package itself is attractive enough for people to at least buy one and try it." He says repeat sales have been tremendous, and he hasn't had a single customer come back disappointed. The growlers are also available at many other area stores. WBC plans to proffer its ales in 12-ounce bottles at some point in the future, but the automated bottling equipment is costly.

LaFortune speaks of a "microbrew revolution" sweeping the country, though he shrugs off the word "trend." "People's tastes are changing and they are starting to demand quality and flavor." The taste for premium beer brewed locally in small amounts (by definition, a microbrewery produces less than 15,000 barrels a year) will not

Brewing by the Numbers:

The Single-Infusion Mash Brewing Method Used for Wachusett Country Ale

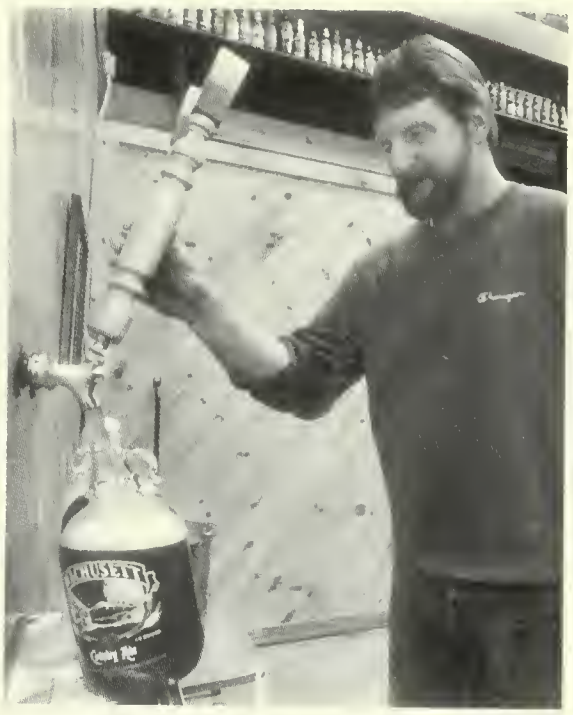
Ingredient 1 — Water
Water from a groundwater well is heated overnight to the proper temperature in the brew kettle.

Ingredient 2 — Malted Barley
Cracked malted barley (four types of malts are used) is mixed with the hot water in the mash "tun," creating the mash. The mash is held at a constant temperature for 90 minutes. Hotter water is then sparged, or forced, through the mash bed. The resulting liquid "wort" is collected in the brew kettle.

Ingredient 3 — Hops
The wort is brought to a boil and two types of hops are added at different intervals during the 90-minute boil (early hop adding for bitterness, late for aroma). After the boil, the wort is whirlpooled in the kettle, which brings the proteins and solids to the center of tank. The wort is chilled with a plate-frame heat exchanger, lowering its temperature from 200° to 63° F. It is then transferred to the fermenter.

Ingredient 4 — Yeast
Yeast is pitched into the fermenter and fermentation begins. The ale remains in the fermenter for one week and then is transferred to a conditioning tank for another week. The yeast is collected from the fermenter for use with the next batch. The ale is transferred to a second tank for an additional week of conditioning. The last transfer is to a bright tank for a week of maturation. It is here that carbon dioxide levels are adjusted to the proper level. Kegs and growlers are packed from the bright tank; the ale is delivered fresh within hours of packing to accounts in Central Massachusetts.

Above, Kevin Buckler, center, and Ned LaFortune III, right, prepare a conditioning tank, while James Krauss looks on. Right, Ned's father, Edward LaFortune Jr., fills half-gallon "growlers" from the bright tank, the final step in the brewing process.



decline, despite the higher price, LaFortune insists. "Once you've become accustomed to tasting beer for quality and flavor, you cannot go back to something that does not have flavor, texture, color," he says.

"At $1 more per six-pack over mass-produced premiums," he continues, "you're getting more alcohol, more flavor, more enjoyment." LaFortune refuses to stereotype consumers of small-label beers, since he sees devotees from different income brackets and all walks of life. He adds that microbrews are designed to be enjoyed and are actually in tune with the current message of alcohol awareness, because quality beer encourages people to "drink less, drink better."

The Northwest is a boiling pot of microbrewing, says LaFortune, and New England is just beginning to see some action. He predicts that in five years the region will be inundated with microbreweries. In the Worcester area, another microbrewery is in the planning stages, along with several "brew pubs"—establishments (often with restaurants) that make small quantities of beer to be served on the premises. WBC welcomes the competition. "It just fuels us," says LaFortune, predicting that brew pub patrons will go to the liquor stores looking for equally high-quality products. "We look forward to having the brew pubs come to Worcester, because it creates a taste for handcrafting and an awareness of the microbrew revolution. That's what Worcester County needs."

LaFortune returned to the classroom last January, at the invitation of WPI's Entrepreneurs Collaborative, to address students in a course titled Introduction to Entrepreneurship. He was billed as the youngest speaker in the series, and his company was undoubtedly the newest venture, the first kegs and bottles having rolled out barely a month before.

Standing behind the lecturer's desk, which was decorated with green cardboard "table tents" and gleaming growlers full of Wachusett Country Ale, LaFortune literally donned each of the three hats he wears as a company president—sales rep, distributor and assistant brewer. He earnestly shared the trials and tribulations of launching a business, from dealing with regulatory agencies and the high cost of insurance, to watching the print on the first batch of growlers rub off in his hands.

LaFortune's advice to those who want to follow in his footsteps: "Pick your area, define it, and be the brewery of that area." Although they would consider expanding into the Boston area (and have already been approached by establishments that want to carry their products), WBC's owners have no immediate intention of leaving Worcester or expanding beyond Massachusetts. "Our goal is to be the predominant brewery of Worcester County," says LaFortune. "We want to have our ales in every establishment that wants to carry them—whatever size that takes us to."

Ned, Kevin and Pete say students and alumni are welcome to visit the brewery and sample their ales. Tours are run at 175 State Road East (Route 2A), Westminster, Mass., on Saturdays at 1 and 3 p.m. Call 508-874-9965 for information.

Did Indiana Jones Go to WPI?

By Joan Killough-Miller

When filmmaker George Lucas first dangled the idea of an adventure film with a swashbuckling archaeologist hero before director Steven Spielberg, it's not likely that either one spoke of Edward Thompson. Yet the notion that Thompson, who first made waves in archaeological circles back in 1879 while still a WPI student, is part of the fictional character of Indiana Jones is as tantalizing and elusive as...well, as the Lost Ark of the Covenant that Indy risks his life to uncover in *Raiders of the Lost Ark.*

The Discovery Channel has no trouble seeing Thompson as Indiana Jones—or at least as one of several "real life Indiana Joneses" who will be portrayed in a four-part documentary scheduled to air this summer. *Seekers of the Lost Treasure,* filmed by Atlantic Productions of London, tells the stories of "four daring adventurers who braved the challenges of the unknown to bring home priceless artifacts from far off lands" (see box for broadcast details). Episode 2, "Thompson and the Well of Sacrifice," is bound to have its share of venomous snakes, superstitious natives, poisoned arrows, and other occupational hazards of working in remote jungles.

Had Lucas or Spielberg heard of Thompson? Lucas biographers trace the origins of the archaeologist-adventurer character to anthropology courses the filmmaker took at Modesto Junior College, but no specific individuals are named. Deborah Fine, director of research at Skywalker Ranch, insists that there is no "real" Indiana Jones and denies that any anthropologist or other scientist was the model for the character. She says she has heard from many, many people who believe they knew who the inspiration was, or who have claimed the honor for themselves.

Edward H. Thompson of Falmouth, Mass., and his sister, Virginia Kirkendall of Upton, Mass., are the last survivors of the archeologist's 17 grandchildren. Their aunt Alice traveled to Mexico in 1885 as a 2-month-old infant; their father, Edward, was born there, followed by two more sons and another daughter, all raised by Henrietta

Edward Thompson

Thompson in the remote Yucatán jungle. Mexico was the family's home for 40 years, although Kirkendall says her father was sent back to Cambridge at age 16, speaking only Spanish, to get a proper education. The senior Edward Thompson, sometimes called "Don Eduardo," returned to New England at age 65, a leading authority on Mayan relics and civilization.

Edward Herbert Thompson was born in Worcester in 1860 or 1857, depending on whether one believes him or the family Bible. His earliest memories were of searching for arrowheads in the brooks of Athol, Mass., where he spent summers, and by the banks of Lake Quinsigamond. Thompson entered WPI in 1875, failed at the end of his first year, and returned in 1876 with little better success. He studied Japanese, with the intention of going to Japan to investigate the Ainus, "that mysterious white race of the Flowery Kingdom," but was sidetracked by his fascination with the lost continent of Atlantis.

In 1879 he published an essay called "Atlantis Not a Myth," in which he claimed that descendants of the race that once inhabited the sunken kingdom migrated through the Americas and formed the Mayan civilization. Although he later discredited his theory, the article brought the WPI student to the attention of the American Antiquarian Society in Worcester and its vice president, Stephen Salisbury II. Salisbury, who was also president of the WPI Board of Trustees, invited Thompson to dine with him and U.S. Senator George Frisbee Hoar, who was also on WPI's founding board. Salisbury had been asked by the Antiquarian Society to find someone to search for remnants of the Mayan civilization in the Yucatán Peninsula. He thought Thompson was the right man.

Thompson was thrilled at the prospect. After the meeting, Hoar arranged for Thompson to be posted to the Yucatán as American Consul to Mexico. From his base at Merida, Thompson explored Mayan ruins and immersed himself in the culture of the natives, "descendants of the ancient builders and calendar makers." He learned their language, ate their food, and participated in their sacred rites. Thompson later purchased and restored an abandoned plantation, which included the ruined city of Chichen Itza, ancient capital of the Mayan civilization and site of the Sacred Well of Sacrifice.

Thompson bade farewell to the Yucatán in 1925, in the face of mounting troubles. His plantation had been burned by Mexican revolutionaries and rebuilt at his own expense, minus priceless artifacts and irreplaceable

Seekers of the Lost Treasure

At press time, the four-part documentary, narrated by Jeremy Irons, was scheduled to air on the Discovery Channel in late July. Episode 2, "Thompson and the Well of Sacrifice," was set to premiere on Sunday, July 30, between 10 and 11 p.m., and to be rebroadcast Aug. 6 between 1 and 2 a.m. Readers are encouraged to check their local listings, as last-minute changes are possible.

research materials. The Mexican government then attached his property under a lawsuit that claimed he had illegally removed valuable artifacts from their country of origin. Thompson retired to West Falmouth, where spent his last decade lecturing and writing his memoirs.

Having published the scientific details of his findings in academic journals, Thompson reserved the highlights of his action-packed career for *People of the Serpent,* his autobiography. Lurking behind the vivid descriptions of Mayan rites and ruins is a playful storyteller with a love for drama. His tales of derring-do rival the adventures of Indiana Jones, who has been called "an archaeologist hero with the grit of Bogart, the dash of Gable and the fearlessness of Superman."

Thompson's descent into a cistern in the ruined city of Labna, for example, bears a strong resemblance to one of the most memorable scenes in *Raiders of the Lost Ark.* Moviegoers who recall Indiana Jones trapped in the Well of Souls with thousands of slithering snakes will delight at the image of Thompson, wearing a high-crowned, narrow-brim hat, a hunting knife clenched between his teeth, being lowered by rope into a cavernous chamber. The explorer lands softly on a pile of debris that turns out to be a very large rattlesnake.

"The situation grew rapidly acute," he writes, "for his eyes were turning bottle green, his jaws dripped saliva, and a strong odor like musk filled the unventilated space of his chamber, and gave me a feeling of nausea. It was clearly time for me to make a move."

There are no rocks handy for defense, and Thompson fears that a bullet from his revolver might start a cascade. "A still better reason for not using my revolver was that I did not have it with me," he tells us, adding that in the jungle he was rarely parted from his gun. Backed up against the wall, our hero feels a buckling in the mortar of the well, which, he takes time to note, has been caused by centuries of settling soil and the growth of tree roots. Thompson is able to work loose a chunk of mortar with which to crush the rattler's head. Other chapters of his book are packed with sharks, pythons and jaguars, as well as runaway horsecarts and death-traps set by desperadoes.

He left the Yucatán lame in one leg from a brush with a poisoned arrow, bald from jungle fever, and partially deaf from his descent into the Well of Sacrifice.

Top, the temple of Kukil Can (the feathered serpent), the heart of the city of Chichen Itza. Bottom, the Date Stone, an aid in working out the chronology of the Mayan civilization.

When Thompson writes, "I have squandered my substance in riotous explorations," he means it literally. He left the Yucatán lame in one leg from a brush with a poisoned arrow, bald from several bouts of jungle fever, and partially deaf from descending into the Well of Sacrifice in a 19th century diving suit. (Hearing of his plan to dive into the well, his colleagues said, "No person can go down into the unknown depths of that great water pit and expect to come out alive. If you want to commit suicide, why not seek a less shocking way of doing it?")

Thompson downplayed the monetary value of the fragments of jade, gold and bone he brought to the surface, insisting that he quested only after knowledge. "The historian delves into the past as the engineer digs into the ground, and for the same reason, to make the future secure." The Mexican government disagreed. Only after his death in 1935 was Thompson's name finally cleared. The Mexican Supreme Court ruled in 1944 that the archaeologist had not violated any laws that were in existence at the time he removed the goods. In 1976 Harvard University agreed to return to Mexico Thompson's contributions to the Peabody Museum's collection of pre-Columbian jade.

The Thompson grandchildren say their grandfather was one of the few archaeologists of his time who worked for scientific advancement, and not for profit. They have no treasures in the attic or cellar from the Mayan Empire, only trinkets—and memories of a talkative but modest man. The living Edward Thompson says he learned more about his grandfather from the research and filming of the Discovery documentary than he had ever known. "I couldn't figure out why they were bothering to portray a relatively obscure archaeologist," he says. "No one in the family perceived him as being famous. He was just Grandfather."

As for Edward Herbert Thompson, he was clearly content with own reputation and deeds. "...I am altogether satisfied," he wrote in *People of the Serpent.* "The reward of a labor of love lies in the performing of it, and I can look back upon a career as full of incident and adventure as any man has the right to expect."

Country Ale

WPI JOURNAL

SUMMER 1995

Meet Edward Parrish

Our 14th President Intends to Make A Name for WPI

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Front cover: Photo by Jonathan Kannair. Story on page 4. Back cover: The interior of the First Presbyterian Church in Stamford, Conn., one of Wallace Harrison's most awe-inspiring designs. Story on page 8. This page: An illustration of a scene from Charles Dickens' *The Old Curiosity Shop*. Story on Page 10.

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WPI JOURNAL

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Alumni Find a (Cyber)Space All Their Own

When last we visited the brave new world of cyberspace ("Another Spin on the Information Highway," Winter 1995), the WPI Alumni Association was engaged in a search for the best way to link its members to the Institute and the association through the Internet. Under the leadership of Harlan Williams '50, an ad-hoc committee of the association had begun looking for cost-effective ways to get alumni connected to the Net, and through it, to WPI.

The committee conducted a survey of younger alumni that showed that about nearly three quarters have computers with modems in their homes or offices and are interested in using them to stay in touch with their alma mater. The group also looked at how a number of other colleges and universities have opened Internet doorways to their graduates and talked to potential Internet "providers."

Along the way it became clear that the on-line communications landscape is changing rapidly. Companies and on-line services that provide access to the Internet are proliferating, and the cost of getting connected is becoming more affordable all the time. Given these changes, and the fact that so many alumni already use the Internet, it no longer seemed necessary to worry about finding alumni a suitable on-ramp for the information highway. Instead, the committee decided to look at what alumni might like to find once they get connected.

Last year, the Institute launched a service on the World Wide Web that offers easy access to a variety of information about the university (http://www.wpi.edu/). The Alumni Office and the Alumni Association are represented there with pages of information that describe the association's programs and events. While alumni who've visited WPI's Web pages have been enthusiastic about being able to roam our virtual campus and check in on what's happening on the Hill, they've also expressed an interest in services that WPI does not currently offer on its Web site, notes Williams.

"Alumni want access to the kinds of information WPI maintains in its alumni database, so they can look up their classmates and friends," he says. "They want to be able to talk to fellow graduates on-line and send them e-mail. They also want to be able to buy products from the college bookstore. But WPI can't put confidential information about its graduates on a network freely accessible to millions, and it doesn't have the computer or human resources to offer a special on-line service just for its alumni."

The committee found a solution to these and other problems in a service offered by Alumnet Services, a communications and networking company in Austin, Texas. Alumnet Services enables colleges and universities to create secure sites on the World Wide Web for use solely by their graduates. Alumni pay a modest annual fee and receive a password that allows them to access the service. Among the creators of Alumnet was Mihran Aroian, who earned a bachelor's degree in life sciences at WPI in 1980.

"Alumnet is about communications," Aroian says. "It makes it easy for alumni to communicate with each other, and for the college to keep in touch with its graduates. Graduates who sign up will be able to talk to one another via e-mail and in public and private chat rooms; leave messages on electronic bulletin boards about topics that interest them; and search an on-line alumni directory. They will also find a secure way to shop for WPI products or sign up for events and travel programs on-line. As a WPI graduate myself, I feel these are the kinds of services that other graduates will find useful and fun."

WPI's Alumnet service is scheduled to debut by the end of the year, according to Sharon Davis, director of alumni programs. "For just $45 a year," she says, "alumni will get all of the services Alumnet provides. These include an on-line 'auditorium' where alumni can talk to special guests from WPI and our alumni body, the opportunity to create an on-line 'profile' for other users to read, job listings from WPI's Career Development Center, and a hot link to the WPI Web home page."

To get more information about WPI Alumnet call the WPI Alumni Office at (508) 831-5600 or send an e-mail message to scdavis@jake.wpi.edu. Readers can also send a message to subscribe03@wpi.alumnet.com, or use their Web browsers to fill out an on-line subscription form. The address is http://wpi.alumnet.com/.

A Final Note: You may have noticed something different about the *WPI Journal*. From a bolder, more attention-getting cover, to a new contents page, to a new format for our department pages, we've given the magazine a new look. To celebrate, we've included some extra color in this issue. We'd love to hear what you think.

—Michael Dorsey

Small Does Not Mean Mediocre

TO THE EDITOR:
In a letter in the Spring 1995 *WPI Journal*, Bruce and Allison Nunn implied that, because of its size, WPI could offer no more than a "mediocre education" as a university. Let me tell you about my undergraduate alma mater.

I was one of about 1,800 undergraduates then; it's a little larger now—about the size of WPI, in fact. Both the College of Engineering and the College of Arts and Sciences were then, and are today, among the best in the world. The professors who taught my biology and chemistry courses were all world-class research scientists. Several had authored the textbooks that I and thousands of other students across the country used, and a few were members of the National Academy of Sciences. Many of the faculty in the various liberal arts departments were also internationally renowned scholars.

Size is no impediment to an institution that has the will, the wisdom and the leadership to be a first-class university. During the 10 years that I served as head of WPI's Department of Biology and Biotechnology, I often told prospective students and their parents that my goal for the department was to provide an undergraduate education as good as mine at The Johns Hopkins University.

—JOSEPH C. BAGSHAW, HOLDEN, MASS.

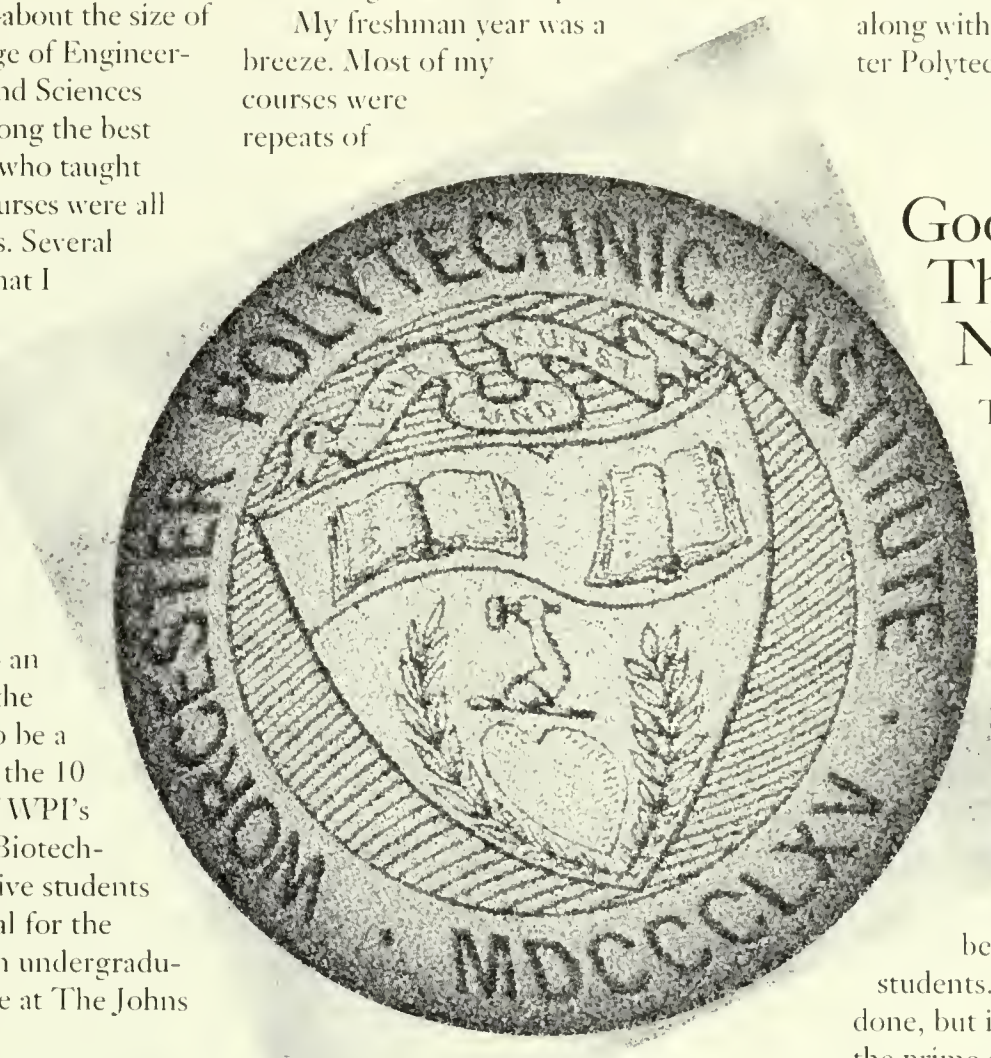
Bagshaw is professor of biology and biotechnology at WPI.

"University Plan" May Harm WPI's Reputation

TO THE EDITOR:
When I read "Repositioning the Institute" in the Fall 1994 issue of the *WPI Journal*, I was tempted to write a letter to the editor. I did not do so, for, I thought, "Who am I to tell WPI how to run the Institute." Upon reading the letter to the editor by Bruce and Allison Nunn in the Spring 1995 issue ("Will the New WPI Be a Downsized University?"), I changed my mind. I would now like to make a few comments.

I received a B.S. degree in civil engineering from WPI in the spring of 1942. I spent my freshman year, not at WPI, but at Tufts University, as I had the idea of becoming a doctor. Motivated by the fact that my mother was dying of cancer, medicine seemed an appropriate avenue of study. About the second week into my first semester, I realized that for me, that decision was a mistake. My first love was engineering, and a transfer to the school of engineering was arranged with little problem.

My freshman year was a breeze. Most of my courses were repeats of courses I had taken in my senior year at Williston Academy. Life was great. I was initiated into Delta Upsilon fraternity. I played on the soccer team in the fall, the wrestling team in the winter, and the golf team in the spring (on the university's own nine-hole course).



Why did I transfer to WPI? It was because WPI had the reputation of being one of the finest engineering schools in the East. It was my money, I thought, so why not go to an outstanding engineering school? Had I wanted a more liberal education, I would have stayed at Tufts.

WPI's reputation was great enough that, even though I was a civil engineering graduate, I landed a job with the U.S. Bureau of Ships as a junior engineer; later, I became an engineering officer in the U.S. Naval Reserve. In 1947 I started a small ready-mix concrete company. Over the next 37 years, the training I received at WPI stood me well.

What I am trying to say is that, yes, WPI might attract a greater variety of students with a "university plan," but would it rather become just another school offering a hodgepodge of courses, or would it rather maintain its reputation as one of the finest engineering schools in the East and the prestige that goes along with receiving a degree from Worcester Polytechnic Institute?

—ROBERT W. SEARLES '42
BROOKLYN, CONN.

Good Schools Thrive Without Name Changes

TO THE EDITOR:
Congratulations on a superb issue of the *WPI Journal* (Spring 1995). It was extraordinarily illustrative of the diverse nature of the excellent education students may obtain at WPI.

With the current effort to portray WPI as more than a narrow engineering school, I wonder if copies of the *Journal* are being sent to advisors of high school students. Perhaps this is already being done, but if not, it should be sent to some of the prime sources of engineering students, such as Brooklyn Tech (my high school), Lane in Chicago, and all the schools that have produced Westinghouse Scholars.

Obviously, it is not possible to send a copy to every high school in the country. Perhaps those of us who live outside of the larger population centers could pass our copies on to the local high school.

It seems that one of the changes being considered to emphasize the diverse education available at WPI is a new name for the Institute. I would like to point out that there are several institutions (MIT and Cal Tech come to mind) that have avoided such a cosmetic change and are still perceived as providing a pretty good education. Even the first engineering school in the country, Rensselaer Polytechnic Institute, manages to thrive on its original name.

—EUGENE V. KOSSO '46, GUALALA, CALIF.

Stepping Into the Spotlight

Edward A. Parrish has chaired an electrical engineering department at a large university and served as a dean at another. He holds positions of national prominence in the engineering and educational communities. He is widely regarded as a researcher, an educator and an administrator. Now, as WPI's 14th president, he hopes to bring the Institute the national recognition it deserves.

By Michael Dorsey

Parrish, right, starts his first week on the job with a tour of the campus given by Stephen Hebert '66, vice president for administration and treasurer.

J.P. LANGLANDS

This spring, when he learned that WPI had selected him to be its 14th president, Edward A. Parrish was delighted, although he realized it meant taking on a host of challenges, not the least of which was learning how to say the name of his new employer. "I still can't pronounce Worcester," he says, "although I am working on it. People from around the country have been calling to congratulate me, and I hear them say Worcester all sorts of ways. I try not to listen, because I really do want to be able to pronounce it correctly."

A native of Newport News, Va., who has spent all of his working life below the Mason-Dixon line, Parrish can be forgiven if he finds it difficult to get the hang of pronouncing the jumble of letters that adds up to WPI's home city. But he is ahead of many people outside of the Northeastern United States in recognizing Worcester Polytechnic Institute as an innovative and high-quality institution for technological higher education. Doing something to expand WPI's reputation—removing the bushel that covers WPI's light, as he has put it—will be one of the highest priorities of his administration.

WPI needs to be better known for a number of reasons, Parrish says. Most important, a broader reputation can translate into a larger pool of potential students and an easier time in obtaining funds from government agencies, philanthropic foundations and corporations. But it is also true, he says, that the Institute truly deserves to be widely recognized for the innovative approach to technical education that it pioneered a quarter century ago. It is an approach, Parrish says from personal experience, that is little known even among educators

"The National Science Foundation is funding several consortia of technological institutions that are seeking to re-engineer the engineering curricula," he says. "I serve on the board of directors of one of those coalitions. The big surprise for me, as I've learned more about WPI these past few months, is that these groups are hoping to design the WPI Plan. They're trying to do what WPI has been doing for 25 years, and they don't realize it."

Since WPI may already have invented the solution other educators are seeking for integrating engineering with the liberal arts (educating engineers and scientists with an appreciation for the humanities and the social sciences and humanists who understand technology), Parrish says he thinks the engineering community should spend some time getting to know the university and its undergraduate program better. "I'd like to get the National Science Foundation to fund a study of how WPI's graduates have done in their careers and lives, compared to the graduates of more conventional technological programs," he says. "WPI is about the only university in a position to conduct such a longitudinal study. I think the results will not only establish the value of the Plan, but provide a vehicle for bringing it national attention."

Along with an NSF study, Parrish says the best tools at his disposal for spreading the word about WPI may well be his own experience as a scholar, educator and administrator, and his own national visibility within the engineering and educational communities. For the past six years, for example, he has served on the Engineering Accreditation Commission (EAC) of the Accreditation Board for Engineering and Technology, the association that accredits engineering programs at the nation's colleges and universities (including WPI's programs in chemical, civil, electrical, manufacturing and mechanical engineering). He recently became chairman of the EAC, which gives him responsibility for overseeing the teams that visit campuses to evaluate engineering programs for continued accreditation. For someone who hopes to educate the engineering education community about the value of the WPI Plan, the position should be a bully pulpit, he says.

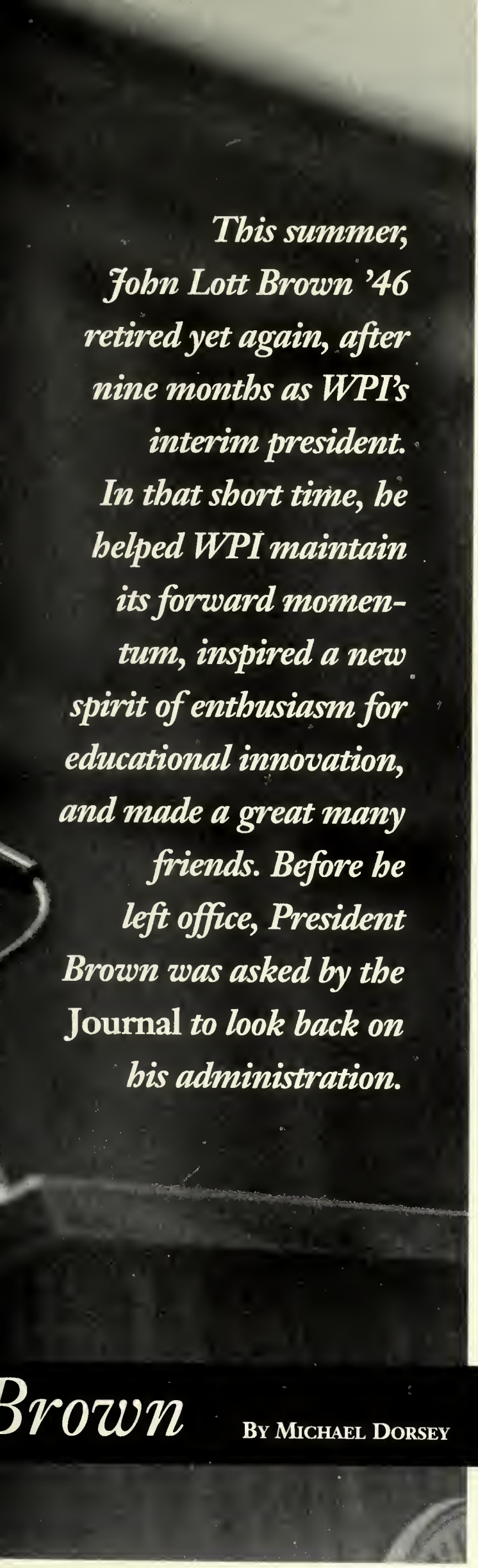
Within the ranks of electrical engineers, Parrish is also a well-known name. He has held more than six dozen posts within the Institute for

(Continued on page 12)

HAIL AND FAREWELL

The Interim Presidency of John Lot

JANET WOODCOCK



This summer, John Lott Brown '46 retired yet again, after nine months as WPI's interim president. In that short time, he helped WPI maintain its forward momentum, inspired a new spirit of enthusiasm for educational innovation, and made a great many friends. Before he left office, President Brown was asked by the* Journal *to look back on his administration.

Brown

By Michael Dorsey

It was a splendid summer day in Worcester as 84 young men, all but eight in Navy blues, marched over the Earle Bridge and into Alden Memorial. They were the members of WPI's Class of 1946—those who had not left early to serve the war effort—graduating a year early as part of the U.S. Navy's accelerated V-12 program. For most of those 84, the ceremony would inspire mixed emotions.

"The war in Europe was over," says John Lott Brown '46, "but we did not know that nuclear weapons would soon bring about a rather rapid end to the war in the Pacific. We didn't know how much longer we'd be in the Navy when we left WPI. So while it was a happy time, it was also a time of some anxiety, because we didn't know what the future held for us."

Five decades later, Brown attended another WPI graduation exercise. Once again, it was a grand, sunny day, and once again, the audience (now filling most of the Quadrangle) included many young graduates wondering what the future would bring them. But this time, Brown was not among them. As interim president of WPI, he presided over the ceremony from the stage, an experience he says was "a real kick."

"It was a great experience to be there, 50 years after my own graduation," he says. "You can't really describe the emotions you feel in a situation like that. It was just thoroughly delightful. I had the privilege to shake hands with some 800 people as I handed out the diplomas.

"Now I would have settled for half that number, in terms of the thrill involved, but I enjoyed every minute of it," he adds. (Having suffered a shoulder separation earlier in the year while skiing, Brown had been exercising his right arm for several weeks prior to the ceremony by squeezing a hard rubber ball. "That exercise didn't hurt a bit," he says, "because there are always a few students who really want to put the squeeze on the president's hand to see how far they can get. With the exercise—and getting the proper grip—I was able to hold my own, though.")

The spring Commencement marked the end of the 1994-95 academic year, a year that began with the departure of Jon C. Strauss, WPI's 13th president, and the subsequent search for a person with the right background—and the willingness—to take on the responsibility of leading the Institute for the year or more that would be needed to conduct a formal, national search for a new chief executive officer.

The Executive Committee of the WPI Board of Trustees considered a number of candidates and narrowed the list to a few finalists. Prominent on that short list was the name John Lott Brown. "I was approached in late August and asked if I wanted to be a candidate," he says. "I didn't have to think about it very long. I've been involved with WPI for a long time, as a student, an alum and a member of the board. As an educator myself, I've taken great pride in the WPI Plan, more so because my friend and classmate Bill Grogan '46 had such a significant role in making it work. I told them that, if they believed me to be the best person for the job, I would, without reservation, accept."

After interviewing the finalists in Boston, the Executive Committee voted unanimously on Sept. 12, 1994, to offer the job to Brown. True to his word, he accepted immediately. "I didn't even ask them how much it would pay," he says.

The committee was impressed with Brown's experience as a college president and his knowledge of and enthusiasm for WPI (see story, page 22). "We have a very significant person here who is willing to serve us as long as it takes us to conduct our permanent search," M Howard Jacobson, then chairman of the Board of Trustees, told the Worcester *Telegram & Gazette*. "He's a distinguished scholar, academician, teacher and administrator. We are thrilled that he is willing to step in at this time.... He will be a great credit to this institution and this community."

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One of a Kind

By Donald F. Berth '57

The Life and Career of Wallace K. Harrison

The Metropolitan Opera House. U.N. Headquarters. Rockefeller Center. What do these landmarks have in common? They were all designed by Wallace Harrison, who began his formal education at WPI. Here is the story of one of the century's greatest architects.

Sept. 28 marks the 100th anniversary of the birth of Wallace K. Harrison, one of the most important architects of the 20th century. Harrison, like Frederick Law Olmstead, the first great landscape architect, was born and raised in Worcester. Unlike Olmstead, who created one of his great legacies, Elm Park, in Worcester, Harrison was never to have a commission in his home city. Both, however, had a major impact on the way we see our modern world, and both left enduring legacies, particularly in New York City.

Olmstead's greatest work was Central Park. For Harrison, the choice could be made from among several monumental building projects, including Rockefeller Center, the United Nations Headquarters, the Metropolitan Opera House, and the Trylon and Perisphere, which formed the centerpiece for the 1939 World's Fair. Harrison's reputation as an architect rested as much on his ability to oversee and coordinate such big projects as it did on the visual impact of the architecture itself.

Though Harrison's work is familiar to most everyone, what readers of the *WPI Journal* may not know is that this internationally renowned architect received some of his seminal training in structural engineering from Arthur W. "Pa" French, professor of civil

DONALD F. BERTH '57

engineering at WPI. Harrison took night courses taught by French, who himself had worked extensively on problems of flat-slab reinforced concrete buildings. Many of Harrison's greatest projects made use of this technology.

What is, perhaps, most remarkable about Harrison's career was the purposefulness with which he pursued it. Harrison's parents, Rachel and James Harrison, both traced their roots to Yorkshire, England. Rachel was in her early 40s and James was 50 when Wallace, their only child, was born. The family lived in a three-decker home on Hathaway Street in Worcester, not far from the Clark University campus. When Wallace was 14, his mother died; not long after that, his father disappeared, leaving the high school freshman to fend for himself.

To get by, Harrison went to work as an office boy at O.W. Norcross, one of the nation's leading construction companies, for a salary of $3 per week. He rented a room from the mother of Norcross' head office boy and began his long climb to the ranks of America's pre-eminent architects. The job at Norcross he owed to Louis W. Wilson, librarian at Clark University, whom he had met at the Episcopal Church in Worcester. In 1910 Wilson advised Harrison to consider two careers: architecture and chemistry, both of which were set to mushroom in the decades ahead.

O.W. Norcross was founded in 1864, just a year before John Boynton made his gift to establish WPI. Founders James and Orlando Norcross, natives of Maine, built virtually all of architect H.H. Richardson's major works, including one of his earliest, the former Classical High School in Worcester, which now houses the administrative offices of the Worcester school system. The firm was also the general contractor for Worcester's City Hall, and it was the contractor for the New York Public Library. It was a remarkable and fortuitous setting for Harrison to find himself in, despite Orlando's attempt to throw cold water on his ambitions by advising him that "only fools practice architecture."

In March 1913, at age 17, Harrison left O.W. Norcross for a job paying $9 a week at Frost & Chamberlain, then Worcester's leading architectural firm. Coincidentally, 1913 was the year that Stephen C. Earle, the city's greatest architect, died. Earle was the dominant architect during Worcester's greatest period of development, and he also designed most of the 19th-century buildings on the WPI campus (Boynton Hall was his first significant commission). While at Frost & Chamberlain, Harrison took his night courses with Professor French. During working hours, he put what he learned at WPI to use as he designed concrete frames for large mill structures at Niagara Falls.

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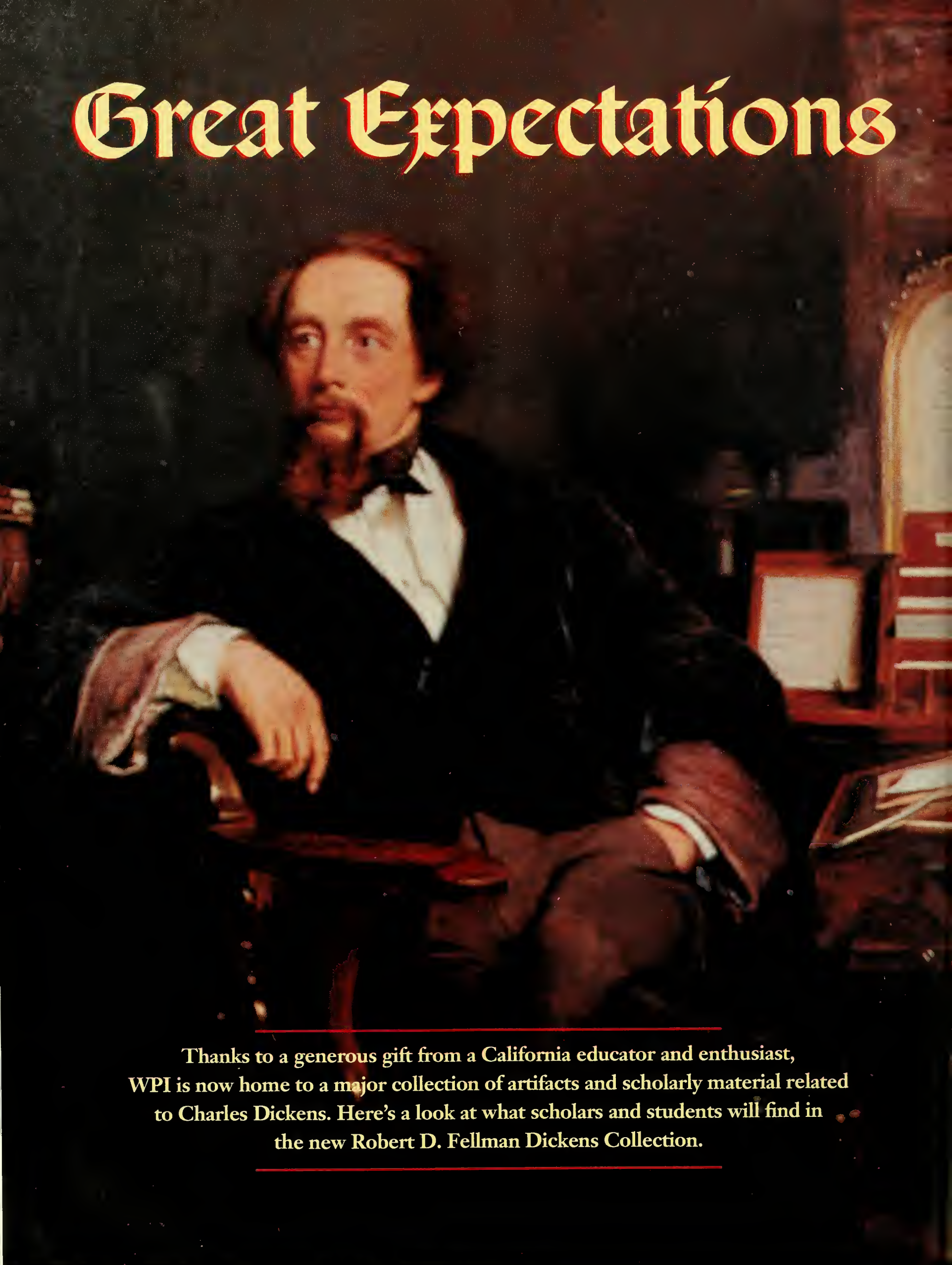
PHOTO COURTESY OF THE UNITED NATIONS

From left, the magnificent bell tower Harrison designed to accompany his stunning First Presbyterian Church in Stamford, Conn. (see back cover); Harrison seated before a model of the Metropolitan Opera House interior; exterior of the opera house; the interior of Radio City Music Hall, part of the Rockefeller Center complex; U.N. Headquarters in New York.

Great Expectations



Thanks to a generous gift from a California educator and enthusiast, WPI is now home to a major collection of artifacts and scholarly material related to Charles Dickens. Here's a look at what scholars and students will find in the new Robert D. Fellman Dickens Collection.

By Joel J. Brattin

Through his brilliant novels, Charles Dickens defined the Victorian era and helped shape our understanding of this important period in British history. This may explain why, after Shakespeare, Dickens is the most studied writer in English. Dickens is also one of the most widely read of all authors, and for excellent reasons. His brilliant characterizations, ebullient humor, vivid and colorful style, and keen observation and deep understanding of the way people think, feel, talk and behave resonate powerfully with readers. Novels like *The Pickwick Papers*, *David Copperfield*, *Little Dorrit* and *Great Expectations*—and characters like Scrooge, Fagin, Little Nell and Pecksniff—take their place among our culture's greatest literary treasures.

WPI recently received a remarkably rich collection of Charles Dickens materials as a gift from a private collector, Robert D. Fellman of Palo Alto, Calif. This generous donation, which will ultimately be housed in a special room in Gordon Library to be known as the Robert D. Fellman Dickens Room, establishes WPI as the premier source for Dickens material in Central Massachusetts. The Fellman Collection contains valuable first editions, unique manuscripts, original and rare illustrations, and fascinating secondary sources from the 19th and 20th centuries—all of extraordinary value to scholars and students of Dickens.

NEIL NORUM

Left, George Cruikshank's famous illustration of "Oliver asking for more" from the original edition of Dickens' *Oliver Twist*. A bound first edition of the novel is among the hundreds of items in the Robert Fellman Dickens Collection. Opposite page, a portrait of Dickens from 1859.

The collection includes more than 100 volumes of Dickens' writings, more than 35 manuscripts and autograph letters, 246 volumes in sets (including the National, Gadshill and Heritage Press editions of Dickens), 168 volumes of Dickens-related periodicals, about 150 volumes of letters, biographies and illustrations, and about 250 volumes of reference works, criticism, and commentary on the novel, Dickens' England, the Victorian period, and related English authors. Also available to scholars are a variety of art objects and a valuable set of Dickens-related slides and videotapes.

This outstanding collection features rare first editions of almost all of Dickens' major works. All of Dickens' novels were originally published serially, in weekly (or more usually monthly) installments, and collections of those original "parts" are of great scholarly interest. The first 19th-century purchasers of such works as *Nicholas Nickleby*, *Doubey and Son*, *David Copperfield*, *Bleak House*, *Little Dorrit* and *The Mystery of Edwin Drood* read these works not in bound volumes, but in paperbound booklets, issued monthly, each number of which included 32 pages of Dickens' remarkable text, two engraved illustrations, and a number of advertisements that reveal much about the habits and preoccupations of Victorian England. The Fellman collection includes copies of all the above-named works in the original monthly installments.

Some of Dickens' novels originally appeared in other periodical forms. *Oliver Twist* was first published in *Bentley's Miscellany*, a periodical edited for publisher Bentley by a youthful Charles Dickens. *The Old Curiosity Shop* and *Barnaby Rudge* appeared first in *Master Humphrey's Clock;* a weekly serial of Dickens' *Hard Times* was published in the Dickens-"conducted" *Household Words;* and *A Tale of Two Cities* and *Great Expectations* made their debut in *All the Year Round*, the last of the journals Dickens edited. With the Fellman gift, WPI now has runs of all of these valuable 19th-century periodicals complete through 1870, the year of Dickens' death.

In addition to the original part publications, the Fellman collection boasts fine bound first editions (usually bound from periodical issues, or printed from the same plates) of *Pickwick Papers*, *Oliver Twist*, *Nicholas Nickleby*, *The Old Curiosity Shop*, *Barnaby Rudge*, *Martin Chuzzlewit*, *Dombey and Son*, *David Copperfield*, *Bleak House*, *American Notes*, *The Life of Our Lord*, *Little Dorrit* and *Our Mutual Friend*.

But the first editions are only the beginning of the riches in this outstanding collection. As part of Fellman's extraordinary gift, WPI received eight original autograph Dickens letters—several of substantial length and significance. Four of these letters, published only recently, were written to Joseph C. King, a London schoolmaster, and discuss the education of Dickens' sons Walter and Charley. In the earliest of these, dated Feb. 24, 1849, Dickens tells

(Continued on page 26)

Stepping Into the Spotlight

(Continued from page 5)

Electrical and Electronics Engineers, many at the national level. In 1988 he served as president of the IEEE Computer Society. He was a member of the IEEE board of directors from 1990 to 1993 and has been vice president of educational activities. He served as an IEEE delegate to the U.S.S.R. in 1977 and to the People's Republic of China in 1978. In 1980 he returned to China as the co-director of an IEEE Computer Society delegation. He went to China again in 1983 and 1984 as general chairman of the First International Conference on Computers and Applications. In 1990 he returned to Russia as part of a three-person group invited by the Popov Society. Earlier this year, he was named editor in chief of *IEEE Computer*, the journal of the IEEE Computer Society. For his contributions to pictorial pattern recognition and to engineering education, he was named a fellow of the IEEE in 1986.

JONATHAN KANNAIR

Parrish meets the press on May 19, 1995, just after his election as president by the WPI Board of Trustees.

Parrish's own road to a career as an engineer and educator began as a teenager in Newport News, where he delighted in poking around the insides of the family television set to see how it worked. With the encouragement of his parents, Molly, a director of remedial reading in the public schools, and Edward Sr., a real estate appraiser, he decided to join the service after high school. In 1954, after a brief stint in the Naval Reserve, he enlisted in the Air Force and found himself assigned as an air traffic control instructor in Biloxi, Miss.

After an honorable discharge in 1958, he enrolled as a freshman electrical engineering major at the University of Virginia at Charlottesville. During his junior year he left the university to take a job as a senior programmer and project head at Amerad Corp. in Charlottesville. Over the next three years, he headed a team that developed software for modeling and computer graphics. A fellow programmer at Amerad, Shirley Johnson, a 1961 Vanderbilt graduate in mathematics, would become Parrish's wife a few years later. They have two sons: Troy, a systems analyst who graduated from the University of Virginia, and Greg, who is majoring in electronic art and computer animation at Mississippi State University.

Parrish returned to the University of Virginia and completed his bachelor's degree in 1964. He decided to stay on at the university to earn a master's and a doctorate. During his first two years of graduate study he served as a research assistant in the Research Laboratory for the Engineering Sciences within the school of engineering and applied sciences, where he worked on computer models of silicon-controlled rectifiers, devices that convert alternating current to direct current. From 1966 to 1968 he held a National Aeronautics and Space Administration Fellowship, which funded his research in the area of pattern recognition, a field dedicated to research on computer systems that search for patterns in data, including visual data.

Parrish received his Sc.D. in 1968 and accepted an offer to join the faculty of the department of electrical engineering as an assistant professor. He continued to expand his work in pattern recognition and image processing, publishing nearly 50 papers in scholarly journals over the next 10 years and serving as principal investigator or co-investigator on some 25 research contracts and awards from the Department of Defense, the NSF, NASA and several corporations. He was also a consultant to several high-technology firms and the U.S. Army Foreign Science and Technology Center and he directed three university research labs.

In 1978, Parrish, now a full professor, was named chair of the department, a position he would hold for the next eight years. Over that period he hired several new faculty members, many of whom have taken on positions of leadership in the department and within the university. He developed several new courses that are still being taught. He led the development and enhancement of the graduate research program, and he took on the responsibility for developing and deploying a distributed computing environment for the entire university. Despite the administrative demands of the job, he maintained an active research program, publishing more than 25 additional articles (his list of publications now totals more than 100) and obtaining more than 15 new contracts and awards from government and corporate sponsors.

Parrish says he felt quite content with his professional and personal life in Charlottesville. He routinely turned down inquiries from other universities—until Vanderbilt University came calling in 1986. He had become familiar with the university through his wife and through his own contacts with the Vanderbilt school of engineering. He was impressed with the quality of the faculty and with the university's commitment to increasing the size and quality of the engineering school in order to propel it to national prominence.

Parrish set out immediately to achieve that goal. In his first two years he hired 24 new faculty members; in his eight years on the job he would fill a total of 45 faculty positions, including six new named faculty chairs, increasing the size of the school's professorate by more than 40 percent. Included among those new hires were five women, four blacks and one Hispanic. "I consider building the quality faculty that the Vanderbilt University

School of Engineering now enjoys my biggest accomplishment as dean," he says.

During his term as dean, sponsored research in the school of engineering more than doubled, from $4.3 million in 1987 to more than $10 million in 1994. The school raised more than $18 million in the university's recent fund-raising campaign. And the engineering program led the university in the acquisition of computer technology for teaching and research.

Among his most significant accomplishments as dean—ones he hopes to replicate at WPI—were the significant growth in interest in and applications to the undergraduate and graduate programs, and an increase in enrollment by students able to pay Vanderbilt's full tuition. The latter trend enabled the school of engineering to cap the exponential growth it had been experiencing in its financial aid expenditures.

Between 1989 and 1994, undergraduate enrollment in the school grew by more than 200 to just over 1,200. Not only did the school not have to sacrifice selectivity to achieve that growth, it was forced to institute a waiting list two years ago to avoid enrolling excessively large freshman classes. While most engineering programs—including WPI's—are struggling to enhance their appeal to women and minorities, the Vanderbilt school of engineering can now boast that 25 percent of its students are women and 15 percent are from underepresented minorities (9 percent are black). The geographic diversity of the student body has also expanded, as the school has built up a national—and international—pool of applicants.

A number of initiatives combined to produce those impressive numbers, Parrish says. For example, he says the school ramped up its national marketing efforts and got faculty members, students and alumni involved in helping to convert accepted students into matriculated freshmen. For example, every admitted student receives two or three phone calls from faculty members. A largely student-driven open house on campus shows off the school's facilities and the high level of achievement of its student body. And alumni clubs around the country hold functions for accepted students and their parents, which faculty members attend.

Parrish credits three summer programs developed in the school with helping boost applications—particularly from students able to pay full tuition. One program brings sophomores and juniors from primarily private high schools to campus for five weeks to participate in research, to learn about computers and the Internet, to experience college life, and to see firsthand what engineers actually do. Starting with fewer than 20 students four years ago, the program now attracts nearly 90 students each summer, 75 to 80 percent of whom go on to enroll at Vanderbilt.

A more recent summer program aimed at transfer students has also been highly successful, particularly in attracting students from overseas (like WPI, Vanderbilt does not offer financial aid to foreign students). The school has also worked directly with foreign embassies in Washington, D.C., to build its international student enrollment. Between the two summer programs and the contact with embassies, Parrish says the school of engineering has brought in an average of about 50 full-tuition-paying freshmen each year out of a freshman class that typically numbers 330. To increase graduate enrollment—particularly in a non-thesis master of engineering program that brings in mostly full-tuition-paying students—the school started a summer program for prospective graduate students.

All of these efforts have combined to level off the growth in the school's financial aid budget. "When I became dean, we were spending 11 percent of our tuition revenue on financial aid," he says. "Five years later that figure had doubled. It didn't take a rocket scientist to follow that trajectory—it was going to double again in three years. These programs have made all the difference in the world.

JONATHAN KANNAIR

"At WPI, developing a large, quality pool of potential undergraduates will also be a high priority for me. This will take time and effort by all concerned. The good news is that WPI has an outstanding product to market. As we did at Vanderbilt, I hope to involve the faculty, students and alumni in recruiting efforts. And I want to increase contact with good high schools across the country. Increasing transfer students is also possible, as is bringing in more international students who can add diversity to the student body and bring in tuition revenue. And all of these things can be done with an eye to the financial aid implications."

"At WPI, developing a large, quality pool of potential undergraduates will also be a high priority for me. This will take time and effort by all concerned."

By the time the phone call came from Korn/Ferry International, the search firm WPI used in its national effort to recruit a new president, Parrish was already thinking about the next direction his career might take. He had been a university dean for eight years, and he believed that anyone in such a demanding administrative post needs to change gears after 10 years to avoid getting in a rut.

He considered various opportunities at other universities and was offered the job of provost at one school. But Parrish felt that his experience at Vanderbilt had also prepared him for the demands of a more senior position—college president.

"The school of engineering is an autonomous unit of the university," he says. "As a result, the financial aspects of running the school, in particular, are similar to those of running the university,

Stepping Into the Spotlight

(Continued from previous page)

except for a scale factor. I had to deal with enrollment and financial aid problems. The faculty and I developed a strategic plan for the school that I then carried out via the creation of new faculty positions, new facilities and so on. I had responsibility for development and fund-raising activities, based on our independent needs, which were integrated with those of the university. I also had to deal with a number of personnel issues associated with managing a faculty and staff. These are not all that different than the responsibilities of a president, though the time demands on a president are more intense."

While the time was right to make a move, he had to decide whether WPI was the right destination. From his years of involvement with ABET and IEEE, Parrish had come to know WPI's name and reputation for quality. As he began to look more closely at the college, he was struck by the quality of the faculty, by the admirable degree of collegiality that exists among the faculty and between the faculty and students, by the Institute's rich sense of history and tradition, by the Global Perspective Program, which is setting the pace in global studies among technological universities in the U.S., by the beauty of the campus, and by WPI's location in the heart of New England's high technology belt.

But it was the WPI Plan and the Institute's legacy of educational innovation that impressed him the most. In the Plan, Parrish says he sees the means for increasing WPI's reputation and building a larger and more diverse pool of applicants. But Parrish also sees in the Plan an excellent foundation upon which WPI can build a more comprehensive technological university.

"Comprehensive means different things to different people," he says. "I'm sure some people feel defensive when you talk about making WPI more comprehensive, because it sounds as if you are going to try to slice a fixed budget pie into even more pieces. But on the other hand, if you try to survive as a university over the next 20 years purely on the basis of programs in science and engineering—particularly engineering—it will be interesting to see if you make it. I don't think you will.

"So I think WPI needs to become more comprehensive without losing sight of its roots. That means becoming a more comprehensive *technological university*. I think the directions in which WPI has already begun to move, for example creating "interface disciplines" and building strong programs in the life and biomedical sciences, are quite appropriate. With the growing interest in health care, the biomedical area can be a real draw."

Beyond building on WPI's existing strengths in technology and science, Parrish says the Institute will need to find ways to attract students who are interested in nontechnical majors, but who wish to pursue them in a technical setting. He says WPI can become the hallmark of what he calls the "new liberal arts." "Technology is woven throughout the fabric of our society," he says. "Everybody has to be computer literate. Everybody has to know more mathematics than ever before. It doesn't matter if you are majoring in literature or foreign languages or political science, you will need to understand technology.

"So WPI simply can't afford to focus primarily on engineering—this is another aspect of becoming more comprehensive. What we have to sell is a new liberal arts education, something that a truly comprehensive university, perhaps, can't sell.

"I think the culture at WPI lends itself to such a new liberal arts education, an education that would couple the humanities and social sciences more closely with technological issues—particularly computing and communications technologies. That could be quite attractive to prospective students. If you combine that with the pre-health and pre-law programs that are already being developed at WPI, you evolve into a more comprehensive institution. And it is an evolution, not a revolution, that I see. And I do think it is a matter of survival, at least survival with the kind of quality for which WPI is known."

The WPI Plan, the evolution of a new liberal arts curriculum, and WPI's constantly expanding and widely recognized global projects program are elements of a WPI education that should be particularly exciting to industry, Parrish says, because they enable the Institute to prepare the kind of professionals corporations seem to be clamoring for: young men and women who are self-motivated and entrepreneurial, are able to work in teams to solve problems, can communicate well orally and in writing, and are comfortable living and working anywhere in the world. "There's not another program that is even a close second to WPI" in this regard, Parrish recently told the Worcester *Telegram & Gazette*.

"As we promote the new liberal arts education and WPI's niche in it, I think industry will come to us," he says. "Most of the NSF-funded coalitions have industry backing, because it is widely recognized that today's graduates aren't equipped with the appropriate education to help companies compete in an international economy. The proposed NSF study of our graduates is one mechanism for approaching industry and getting the word out. As more companies learn about WPI and the education it provides, we can expect additional support for projects—both financial and in-kind—and more employment opportunities for our students."

Financial support from corporations and many other constituencies will be very much on Parrish's mind during the early months of his administration, as the university completes its plans for a new major fund-raising campaign. He says it is too early to begin talking about specific goals for the drive,

JONATHAN KANNAIR

"If you try to survive as a university over the next 20 years purely on the basis of programs in science and engineering — particularly engineering — it will be interesting to see if you make it. I don't think you will."

but he says there are a number of needs that almost certainly will be addressed.

"The more obvious priorities for the campaign may not be driven by purely strategic goals; they will be more mundane," he says. "We will want to raise endowment funds for honor scholarships, we will want to create additional endowed faculty chairs so that we can maintain—and build on—the quality of the faculty, and we will need funds to improve the quality of life on campus.

"Under quality of life, I include the campus center that has been under discussion for some time, as well as improvements to classrooms and other educational facilities. In fact, the quality of life, as measured by the infrastructure to support the educational environment, is so important for recruitment and retention, that I don't see how the campaign can help but address it."

As the campaign unfolds, Parrish says he will be looking to WPI's 20,000 alumni for help, not just as donors, but as volunteers to help in all aspects of running this major fund-raising initiative. But that is just one of a number of ways he says he hopes to get graduates involved in advancing the institution.

"We've got to get WPI's secret unveiled," he says, "and alumni are especially well placed to do that. And by helping us get the word out and getting us well known outside of New England, they can help with our recruiting efforts. They can assist in career development, helping students who are coming along find summer internships and co-op opportunities—as well as simply helping students find jobs. Having a strong regional alumni club program can make a difference in all of these things—especially in helping build name recognition—so I think I'd like to stir up that program.

"In my first year or so at WPI I hope to travel around and meet as many alumni as possible, because I'd really like to get a sense of this institution and of what their education meant to them. That will help me figure out where the university has been, and to determine where it should go."

Through the campaign and efforts to make a WPI education more comprehensive, Parrish says his goal will be to strengthen an already outstanding undergraduate program. Another way to accomplish that goal is to maintain and enrich the Institute's graduate program, through which students can now pursue master's and doctoral degrees in more than 30 disciplines. An active graduate program is necessary to sustain a lively program of scholarly research, and research can have many benefits for WPI's educational programs.

"Research is critical for faculty renewal and currency," he says. "It also provides excellent opportunities for students to become involved in exciting projects, allows the faculty to continually improve and update the curriculum, and supports graduate students who can enrich the academic program. In my view, teaching and scholarly work go hand in hand.

"I don't think it is appropriate for WPI to set the kind of goals for research and research sponsorship that a research university can. The thing that sets WPI apart is its curriculum and the attendant interaction between the faculty and the students. That is very labor intensive and would have to be sacrificed to make the university a major research institution. I would prefer to see the faculty maintain a level of research consistent with professional development and a quality graduate program. In addition, very close ties to industry would provide complementary support for the Plan and help market the university."

As for his own life as an active researcher, Parrish says he had to set that aside as the demands of being a university dean began to consume all of his time. When the IEEE approached him last year about becoming editor in chief of *IEEE Computer*, he was hesitant, but accepted the post because having his affiliation printed in every copy of the 110,000-circulation journal was an excellent way to gain visibility for his university. But he also realized that being a journal editor would force him to remain up to date in his field.

"With the demands of work and with my responsibilities at home, I hardly had time to read journals," he says. "They stacked up on my desk and I dutifully put them on the bookcase thinking, 'One of these days...,' but it never happened. But now I have to read many of the papers submitted. I have read more technical papers in the past six months than I had in the preceding six years, though I hate to admit that."

Parrish says his many years of experience as a researcher and a teacher have shaped his approach to managing an academic enterprise. "My goal is to be accepted as a faculty member first, and as president second," he says. "I want to avoid a 'we-they' situation at all costs, because it would be completely counterproductive. I managed to be an administrator and a faculty member at the University of Virginia and at Vanderbilt, and I see no reason why it should be any different at WPI. I have to establish my credibility with the faculty, and that is the first thing on my agenda. Once I have their trust, it will be fairly easy to continue with my normal consultive-participative style of management."

Parrish says the other important item on his agenda as he begins his term as WPI's 14th president is simply to learn as much as he can about WPI—its programs, its people and its history. "I want to get a sense of the place, first and foremost. I have no deep, preconceived notions of what should be changed or improved. Someone once said we all have two ears and one mouth and should be guided by that fact. I want to get to know my faculty colleagues, the staff, the administration and students. Once I feel I understand this institution, it will be time to think about strategic issues and involving the community in addressing them."

"My goal is to be accepted as a faculty member first, and as president second. I want to avoid a 'we-they' situation at all costs, because it would be completely counterproductive."

One of a Kind

(Continued from page 9)

A Career Takes Flight

In the early part of the century, one did not need a degree to become an architect. The usual course for those who aspired to careers in the profession was to apprentice with an established architect, and Harrison followed this route. While apprenticing, the architects-in-training would study architecture under the tutelage of leading practitioners, who offered ateliers, or workshops, in their studios. The fortunate few studied at the École des Beaux Arts in Paris, the pinnacle of architectural education.

While working full time at Frost & Chamberlain and studying at WPI, Harrison enrolled at the Boston Architectural Club's studio and spent his Saturdays studying architectural drawings at

DONALD F. BERTH '57

LOUIS A. BLANCHARD '57

Above, the Corning Glass Center in Corning, N.Y.; right, the Nelson Rockefeller Empire State Plaza in Albany, one of Harrison's last works.

the Boston Public Library. Knowing that New York City was home to most of the nation's top architectural firms, he sailed for the big city and applied for a position at McKim, Mead and White, the most successful firm in the country. Hired as a draftsman at the age of 21, he also enrolled in the Beaux Arts atelier, directed by Harvey Wiley Corbett, who had an engineering degree from the University of California at Berkeley and a diploma from the École des Beaux Arts. Corbett also served as critic and lecturer at Columbia University's School of Architecture.

In 1917, as the U.S. entered World War I, Harrison joined the Navy and was assigned to a submarine chaser. During shore leaves, he studied the architecture of the Azores and Lisbon, and the Roman architecture along the Dalmatian Coast of the Balkan Peninsula. After the armistice was signed on Nov. 11, 1918, Harrison visited Paris and the École des Beaux Arts and enrolled in a local atelier. His earlier experiences and his studies in the Paris atelier won him admission to the école in March 1921, but he left that school a few months later.

In Paris, Harrison became friends with fellow architect Bobby Rodgers, a direct descendent of Naval hero Oliver Hazzard Perry. Rogers introduced Harrison to the artists he knew in Paris, which catalyzed the architect's lifelong interest in developing relationships with creative people. This exposure to the works of young artists also contributed to Harrison's later practice of incorporating major works of art into the buildings he designed. Also during his two and a half years in Paris, Harrison came to admire the spires and belfries of the many cathedrals, presaging the talent he would later demonstrate for working on projects of great height and scale.

Harrison came back to New York in the spring of 1921. He returned briefly to McKim, Mead and White before he and Rodgers went to work for Bertram G. Goodhue, former partner of Ralph Adams Cram. Specializing in the English Gothic style, the Cram-Goodhue firm had designed the West Point Chapel, St. Thomas in New York City, the Heinz Memorial Chapel in Pittsburgh, and Trinity Methodist Church in Springfield, Mass. Now the head of his own firm, Goodhue assigned Harrison to two of his major commissions: the National Academy of Sciences Building in Washington, D.C., and the Nebraska State Capital in Lincoln.

After a grand tour of Rome, Florence, Greece and Egypt in 1923, Harrison returned to Goodhue's office, which was flooded with commissions. It was the beginning of one of many building booms that were to leave a lasting impression on the face of Manhattan. When Goodhue died the following year, Harrison and Rodgers formed their own firm and received some free-lance work from their former mentor, Harvey Corbett. In 1926 Harrison was hired as an associate architect for the New York City Board of Education, later becoming something of an authority on the architecture of public schools. Rodgers died shortly thereafter.

The Rockefeller Connection

In 1926, Harrison, then 30, married the former Ellen Milton, whom he had met two years earlier. Ellen Harrison's brother David was married to Abby Rockefeller, sister of David, John III, Laurance, Nelson and Winthrop. This connection would contribute greatly to the nature and number of commissions Harrison and his partners would receive over the following half century.

The father of these six siblings, John D. Rockefeller Jr., had been responsible for the restoration of Colonial Williamsburg. But that was a modest project compared to his next venture: Rockefeller Center. In the spring of 1929, Corbett, Harrison and William H. MacMurray were brought in as architects for the project. (That same year, the trio designed Bushnell Memorial Auditorium in Hartford, Conn. Its art deco interior would later be mirrored in Radio City Music Hall in Rockefeller Center.) The Rockefeller Center site was originally conceived as the location for a new opera house, but the stock market crash of 1929 postponed those plans. Later, the opera house (a Harrison design) would become part of a major center for the performing arts.

Because of the vast scale of the project, several architectural firms were engaged and the concept of the "group design practice" emerged. Harrison was the only architect to work on the project from its inception to the latest additions in the 1970s. He clearly drew on his studies with Professor French, given the strong structural emphasis of this group of buildings, the first of many megaprojects that would be built in many large metropolitan centers around the world.

The Metropolitan Square Corp., the original name for the group overseeing Rockefeller Center, faced a significant challenge beyond the huge task of designing and building the complex. It was also necessary to find tenants who could afford to amortize the construction costs and carry the operating costs. Harrison is credited with convincing RCA to occupy the central tower and RKO to move into another building at the site. Nelson Rockefeller began work as the chief leasing agent for the center in 1931, a year after his graduation from Dartmouth.

As Victoria Newhouse wrote in her exceptional book *Wallace Harrison, Architect* (Rizzoli International Publications, 1989), "[Harrison's] friendship with Nelson was to develop into a remarkable relationship between a powerful client and an outstanding architect." Like Harrison, Nelson Rockefeller was a devotee of architecture and the fine arts—qualities he learned from his mother.

Radio City Music Hall, a 6,200-seat theater (with no obstructed views), opened on Dec. 27, 1932, and successive elements of the center followed over the next several years. Through Harrison's architecture and skill in leading groups of architects, John D. Rockefeller Jr.'s fortune, and Nelson Rockefeller's persuasive skills, Rockefeller Center became one of the most successful urban developments of the 20th century. For many, the complex and Central Park—both products of the genius of Worcester natives—are New York City's signatures.

The World Comes to New York

Another great "signature," although a transitory one, was the Trylon and Perisphere, the symbol of the 1939 New York World's Fair. Harrison and his partner, J. André Fouilhoux, won a competition to design a structure that exemplified the fair's theme, "Building the World of Tomorrow." The Perisphere was 180 feet in diameter, making it the largest globe ever built. It enclosed an exhi-

A Selection of the Works of Wallace K. Harrison

Rockefeller Center Buildings*
New York City, 1932-1940+

Rockefeller Apartments
New York City, 1936

Trylon and Perisphere and three buildings
New York World's Fair, 1939

Three Mellon Bank Center*
Pittsburgh, Pa., 1951

Alcoa Building*
Pittsburgh, Pa., 1953

United Nations Headquarters
New York City, 1953

Aquarium
Coney Island, N.Y., 1957

First Presbyterian Church
Stamford, Conn., 1958

Corning Glass Building*
New York City, 1959

Rockefeller Center Expansion
(including Time and Life, McGraw Hill and Exxon buildings), 1960-1974

Central Intelligence Agency Building*
Langely, Va., 1961

Hopkins Center
Dartmouth College, Dartmouth, N.H., 1962

LaGuardia Airport main terminal and control tower
New York City, 1964

Hall of Science
New York World's Fair, 1965

Metropolitan Opera House
New York City, 1966

Nelson Rockefeller Empire State Plaza
Albany, N.Y., 1972-1977

Pershing Memorial
Washington, D.C., 1983

*With associated architects
+Year of completion

bition space—larger than the interior of Radio City Music Hall—that contained a vast model of the city of the future that fairgoers viewed from two revolving platforms. The 610-foot-tall Trylon reflected Harrison's interest in tall spires. Harrison and Fouilhoux also designed three buildings for the fair: the Consolidated Edison Pavilion, the Electric Utilities Exhibit and the Electrified Farm.

Joining the Harrison-Fouilhoux partnership during the 1930s was the man with whom Harrison was to collaborate until his last years: Max Abramovitz. His commissions included many of the buildings at the University of Illinois, his alma mater, and many buildings at Brandeis and the University of Iowa, along with the Jewish chapel at West Point. He would also design Avery Fisher Hall at Lincoln Center and the teardrop-shaped Phoenix Mutual Life Insurance building on Hartford's Constitution Plaza. As the nation emerged from World War II, Harrison & Abramovitz was one of two firms that dominated the practice of architecture, the other being Skidmore, Owings and Merrill.

PHOTO COURTESY OF THE UNITED NATIONS

With Harrison are some of the architects associated with the U.N. Headquarters project: from left, Swen Markelius (Sweden), Le Corbusier (France), Vladimir Bodiansky (France), Ssu-ch'eng Liang (China), Harrison, Oscar Neimeyer (Brazil), Guy Soilleux (Australia), Nikolai Bassov (U.S.S.R.), Max Abramovitz, Ernest Cormier (Canada), Ernest Weissmann (Yugoslavia) and Matthew Nowicki (Poland).

The next great Harrison signature work was the United Nations Headquarters in New York City. The city had competed with several other municipalities, here and abroad, to win the complex. It was a gift of an $8.5 million tract along the East River from John D. Rockefeller Jr. that helped tip the balance to New York. In January 1947, U.N. Secretary-General Trygve Lie appointed Harrison director of planning for the agency's permanent home. Harrison had to marshal the talents of many architects from around the world to bring about the final results. Once again, it was his skill in mediating and persuading that helped make him a master architect.

A Magnificent Home for Opera

Because of his ties with Fritz Close, who sold the aluminum used on the exterior of Rockefeller Center, Harrison won the commission to design the Alcoa Building in Pittsburgh, which was completed in 1953. Naturally, the building had to be a showplace for aluminum. What emerged from Harrison's work was the world's first aluminum-skinned skyscraper, a building some 30 stories high. This was followed by a commission from the Mellon Bank, also in Pittsburgh. Richard K. Mellon was a majority stockholder in Arthur Vining Davis' Alcoa. Together the two buildings became major elements in the revitalization of downtown Pittsburgh.

In 1951 Arthur A. Houghton Jr., president of Corning Glass Works (now Corning Inc.), selected Harrison & Abramovitz to design a multi-use center at its headquarters in Corning, N.Y., to celebrate its centennial. A family-owned company founded in 1851, Corning remains one of the largest *Fortune* 500 companies, yet is located in one of the nation's smallest cities. Through the center, the family wished to create a "community" space, an area to exhibit the world's largest collection of glass objects, and a site for the Steuben Glass factory. Since its completion, the building, which houses the finest industry museum in the nation, has been substantially enlarged.

Arthur Houghton was also active in New York City art and cultural circles (he later was to head the Metropolitan Museum of Art and the Lincoln Center for the Performing Arts). He thus had been familiar with Harrison's work going back as far as the period when a new opera house was being planned for the site that later became Rockefeller Center. Houghton and Robert Moses, the city's parks commissioner, approached Harrison in 1955 to see if he would be interested in designing a new opera house.

Moses knew Harrison through his World's Fair projects and believed he had the architectural skills for the project, as well as entreé to wealthy patrons and to the Metropolitan Opera's board. Charles M. Spofford, as chair of the Opera Association's executive committee, convinced John D. Rockefeller III to head the project. Rockefeller was responsible for the fund-raising efforts, Moses was charged with acquiring the land, and Harrison served as lead architect.

Designing and building a world-class opera house is a demanding task, but the city lent additional complexity to the project by deciding to make the opera theater part of a larger center dedicated to the performing arts, one that would serve such constituencies as the New York Philharmonic and the New York City Ballet. In 1958 the group selected the architects for Lincoln Center for the Performing Arts. Abramovitz was chosen to design Philharmonic Hall (later Avery Fisher Hall), Pietro Belluschi was selected to design the Juilliard School, Philip Johnson was tapped for the Dance Theater, Eero Saarinen and Gordon Bunshaft would design the museum, library and theaters, and Harrison, as originally planned, would create the design for the Metropolitan Opera House.

The old New York City Opera House was built in 1883, but was deemed inadequate from the start. A plan for a "new house" emerged as early as the 1920s, but the search for a suitable site took decades. Now that the building would finally become a reality, the focus shifted to its design. Harrison and his associates completed some 43 sets of plans for the building (as well as innumerable design changes, many aimed at holding down the cost of the structure) before the final results

emerged. Nearly 11 years after Harrison received the commission, the 3,765-seat hall hosted its first opera rehearsal (for Puccini's *La fanciulla del West*). As was true of all of the architect's large meeting spaces and theaters, the acoustics were excellent. In fact, the opera house is the only large auditorium in Lincoln Center that has not been redesigned because of poor acoustics. The grand opening of the Met occurred on Sept. 16, 1966, nine days short of Harrison's 71st birthday.

A Jewel in Stamford

During the period when Harrison was entangled with the multiple committees, artistic prima donnas and continual cost containment associated with Lincoln Center, he designed two other significant buildings: the Hopkins Center for the Performing Arts at Dartmouth College and the First Presbyterian Church in Stamford, Conn. The Dartmouth commission was received at about the time he started the opera house assignment. Nelson Rockefeller chaired the trustees' building committee, so once again Harrison's connection to this powerful family helped bring him an important commission. The building was designed and built on schedule and within the $7 million budget.

Like the Hopkins Center, with its distinctive barrel-shaped roof line made of thin concrete shells, the church he designed in Stamford embodied Harrison's personal style. Though a comparatively small commission, the project led to work of great distinction, unencumbered by the merger of ideas typically produced by teams of architects.

Harrison received the commission in 1953 as the church was preparing for its centennial. Recalling the heavy use of stained glass in the great cathedrals of France, he visited Gabriel Loire, a stained glass artist who lived in Chartres, and ultimately selected him to create the glass for the Stamford church. He also visited Visp, near Zermatt, Switzerland, to see abstract designs produced by embedding chunks of glass into wood, stone and concrete. Employing this technique, and incorporating the artistry of Loire, Harrison created a sanctuary made of 152 interlocking reinforced concrete panels inlaid with 20,000 one-inch chunks of faceted, multicolored glass.

The church, completed in 1958, is breathtaking. I first saw the building as a guest of Louis Blanchard '57, whose family were members of the church and part of the Nestlé corporate community. In 1947, Nestlé, in gratitude for the welcome the Swiss company received when it moved its headquarters to the Stamford area during World War II, gave the church a set of carillon bells. In 1968 the bells were reinstalled in a magnificent tower, also designed by Harrison. The bells are supported by four 255-foot concrete posts, and the tower is topped by a 30-foot, 18,000-pound stainless steel spire. "The church was the most satisfying job I ever worked on," Harrison once said. His associate, Michael Harris, said Harrison "knocked himself out for a client like the Stamford church. He received very little pay, but that didn't make him work any less hard on it. He was one of a kind."

A Megaproject in Albany

Harrison's last major project, known today as the Nelson A. Rockefeller Empire State Plaza in Albany, N.Y., took 18 years and cost nearly $1 billion to construct. Rockefeller was then governor of New York and wanted to turn a rather sleepy and rundown Albany into one of the nation's pre-eminent state capitals. Never known for doing things in a small way, Rockefeller developed the basic plan for the huge plaza himself and took a proactive interest in every phase of its development. He even came up with the shape of the meeting space—the "Egg"— the most distinguishing feature of the complex.

The project was a controversial one. Called by some "Rocky's Folly" and the "Taj Mahal on the Hudson," it was known by taxpayers as one gigantic bill. There is no doubt, however, that in scale it rivals all but a few government centers in the world. When Harrison began work on the South Mall, as the complex was initially known, he was 67; when it was completed in 1977, he was 81.

In 1976, five years before his death, Harrison departed from his partnership with Max Abramovitz, who during the Albany mall period worked on several major commissions in the Midwest. Harrison's last commission, which he had received 20 years earlier, was the John J. Pershing Memorial in Washington, D.C. He created the small plaza that served as the setting for the statue of General Pershing, which was sculpted by Stanford White's grandson, Robert White. (Stanford White was the White of McKim, Mead and White, the firm that gave Harrison his first job after leaving Worcester.)

What Harrison learned in those early days, initially at O.W. Norcross and later at Frost & Chamberlain, and then in his classes with Arthur French, he put to good use in a career that fulfilled the lofty dreams of a young boy facing the world alone in Worcester. "It (Worcester) was wonderful," Harrison told Virginia Newhouse, "because you were free to do anything you pleased as long as you didn't interfere with your neighbor." It's unfortunate that Worcester was never home to any of his great creations. At least there is a spirit of his Worcester youth—his dreams and his hopes—that can be seen in some of the greatest architectural works of this century.

—Berth is co-director of WPI's Entrepreneurs Collaborative. He served as vice president for university relations at WPI from 1983 to 1993.

"Harrison knocked himself out for a client like the Stamford church. He received very little pay, but that didn't make him work any less hard on it. He was one of a kind."

Hail and Farewell

(Continued from page 7)

Brown tidied up loose ends at the University of South Florida, where after 10 years as president he had served as director of research centers on urban transportation and microelectronics, and with his wife, Catharine (Katie), he closed up their home in Tampa and headed north in late October, just in time for the start of a relatively snowless New England winter.

Brown says he came to WPI anxious to learn all he could about the state and needs of the Institute, but without preconceived ideas about what he would accomplish during his brief stay. "I didn't come in with any specific goals, because I didn't really have a good enough handle on what the situation was," he says. "I came in with the quite specific intention of trying to find out how things were going, what the various constituencies were doing, and what their needs were."

Brown quickly set out to do just that as he endeavored to get to know as many people on campus as he could. Shortly after settling into his first-floor office in Boynton Hall, he held an open house and invited everyone from the campus community to stop by and say hello. He asked to be invited to meetings of the various faculty governance committees to learn about the issues the faculty was addressing, and he met with a number of student groups to find out what was on students' minds. From time to time he even dropped by the student dining halls to share lunch—and ideas—with students.

He says the ability to meet a good share of WPI's students and employees was in sharp contrast to the world he knew in his decade at the helm of the University of South Florida. "The university has 10 colleges and well over 34,000 students distributed on five campuses," he says. "It has a large medical school, a school of public health, a college of nursing. Each college is a reasonably self-contained unit. At such a large institution, the president is more an image than a real human being. You just can't walk around and talk to all of those people.

"Of course, on a large campus you have a certain degree of anonymity, if you want to preserve it. If people think things are not going well, they may not immediately attribute the problem to you. On a small campus, if the president is seen as part of the problem, the word gets around faster and a lot more people buy into that argument. I didn't have that problem here. Things went well for me. I received a very nice reception and I think people saw me as a person who really cared about WPI and would work very hard to do all I could to help it."

One of the first issues Brown found the need to address was drafting a balanced institutional budget. The fall is the time when WPI's budget for the following fiscal year is proposed, debated and reshaped. While Brown was aware that the process of balancing WPI's budget has been difficult—and sometimes contentious—in recent years, due largely to the rapidly rising cost of meeting students' need for financial aid and the impact of the cost of financial aid on other WPI budgets, he was surprised at how large the budget loomed in the day-to-day affairs of the Institute.

"I found that there was a lot more concern about the budget than I would have expected," he says, "and we spent a great deal more time on the budget than I would have expected before I got here. I'm not sure that the concern and the time we spent were terribly unusual. This is a problem for all institutions of higher education. And it's a problem that is never entirely resolved, unless you are a very wealthy institution.

"One of the problems that plagues private university administrations is the fact that so much of their revenue depends on tuition. When you plan your budget, you can make a number of rather solidly based approximations of the number of students you are going to enroll, but you can't be sure that those approximations are going to come true."

In fact, Brown notes, it appeared that the fundamental assumptions behind the fiscal year 1996 budget, which the Board of Trustees approved in May, were in danger of unraveling when a tally of first-year students paying their deposits for the fall of 1995 proved significantly smaller than the approximation included in the budget calculations. "We had a drop of close to 10 percent from the number we anticipated," he says.

"But because our admissions people had done a rather good job of analyzing the population of applicants and predicting the likelihood of students with various levels of financial need to enroll, we ended up with a very interesting class. Although it is smaller than we anticipated, the students who did not enroll tended to be those who needed the most financial aid. Our yield of students who can afford to pay our tuition was as high as or higher than our predictions. As a result, the tuition revenue, when corrected for the cost of financial aid, will meet our projections."

In addition to that good news, the data on the Class of 1999 painted a changing portrait of WPI's prospective students, Brown says. "We found that we are now competing with a school like the University of Rochester, which is not a narrowly focused technological institution, but a broad-based university. I think we can argue, with considerable justification, that *we* are no longer a narrowly focused technological institution. Our enrollments (some 40 percent of our newly enrolled students now choose majors in nonengineering disciplines) and the fact that we now compete with nontechnical universities lend validity to our claim that we have become a school

"Things went well for me. I received a very nice reception and I think people saw me as a person who really cared about WPI and would work very hard to do all I could to help it."

that offers a much more well-rounded educational opportunity.

"I think I can say that without detracting at all from the caliber of the technological education that people can get here. In fact, I can argue that the caliber of the education that students interested primarily in technology get at WPI is enhanced because they have access to the social sciences and the humanities, which broaden them as individuals. They are also on a campus where the students have a broad range of interests beyond technology, so they can explore these ideas outside of class, as well as in."

The diversity of the undergraduate program is just one of WPI's strengths, Brown says. "WPI is a strong school," he says. "When you list schools of comparable size that have similar areas of academic emphasis, I think you would have to place us near the top of the list, because of the nature of our academic program, because of the quality of our faculty, because of the size of our endowment, and because of the beauty and excellent condition of the campus.

"Now I don't want to leave the impression that everything is fine. We have some dire needs, including the need for more laboratories in several disciplines. Two areas where we have significant needs are biology/biotechnology and biomedical engineering. These are relatively new fields and are very attractive to our applicants. The percentage of the student body choosing those majors is increasing more rapidly than it is for other areas.

"There are other needs, of course. It would be nice if we had a larger endowment, if we had more discretionary income to spend each year, if we had more endowed professorships, and so on. We have to work on those things. Perhaps the most important challenge we face is the need to disseminate information about WPI more broadly throughout the land—including in New England. We need to let people know what kind of school we are. For while we do get students from all over the country, we draw disproportionally from New England, as compared to some other small schools of high quality. Dartmouth, for example, has a much broader reputation around the country than does WPI. If our enthusiasm is justified, than we should be able to significantly increase our applicant pool by getting the word out."

An enthusiastic booster of WPI himself, Brown says he firmly believes that the Institute's graduates can play an important role in achieving that goal. Through its Alumni Admissions Program, the Admissions Office already uses many alumni as diplomats to educate guidance counselors and prospective students about the university and its quality. But, by and large, the alumni admissions volunteers are strictly from WPI's younger classes.

"There is a notion that someone like me is not going to speak the same language as today's high school students," he says. "I don't buy that entirely. I would argue that graduates who've had successful careers, in the fields we emphasize and in the kinds of jobs that interest our students, could be very stimulating to young people. Also, alums of any age, once they've taken the time to read our admissions materials, could talk to guidance counselors and persuade them of the virtues of WPI. I've talked to students from right here in the Northeast whose guidance counselors never mentioned WPI as a place to go for technological education. Even close to home, our image is blurred. We have to try to do something about that."

JANET WOODCOCK

Brown shakes hands with one of the more than 800 students to receive their degrees at the May 1995 Commencement.

The best way to raise WPI's visibility, Brown says, is to emphasize the qualities that make it unique—especially an undergraduate program that gives students tremendous access to the faculty. "Students can get the same kind of information at MIT or Carnegie-Mellon," he says. "They just can't get the same level of contact with the faculty members. The faculty at those institutions are too distracted by their work at the graduate level. I don't mean to diminish the quality of the faculty at MIT—we know they're good. That's why MIT is the leader in technological education at the graduate level. But our strength is undergraduate education, and we do that better than just about anyone."

Though WPI excels at exposing young men and women to the frontiers of science and technology, Brown says it does so with an approach to teaching that has varied little since the Institute was founded 130 years ago. As he explained in a message he wrote for the Spring 1995 *WPI Journal*, "while computer use has permeated the

(Continued on page 23)

COROLLARY

A Career Full of "New Vistas"

JOHN LOTT BROWN '46, a native of Philadelphia, enrolled at WPI in 1942 on the advice of his father, who suggested that a degree in engineering would prepare him for a host of different careers—advice that would prove quite prophetic. Part of the Navy V-12 program, he graduated near the end of the war and completed nearly a year of active Navy duty.

"That brief military service was to have a strong influence on my career," he says. "While serving at sea in the radar division of a cruiser, I was impressed by the educational backgrounds of the senior officers. During the long mid-watches, we had a lot of time to talk. Being with a group of people like that opened up all sorts of new vistas."

Upon leaving active duty, Brown enrolled at Temple University, where he took an assortment of courses, including psychology. Knowing his background, his professor convinced him to build some equipment he needed and then offered to make him a partner in his research, so he could earn a master's degree.

He earned a master's in psychology at Temple and joined Link Belt Co., teaching young engineers how to develop product application estimates for customers. He was later named personnel manager at a foundry. "Then I began thinking that I'd had more fun at the university," he says. "I decided to get a Ph.D."

He earned his doctorate in experimental and physiological psychology at Columbia University. "My mentor there had an Air Force research project to investigate problems associated with the interpretation of information and the nature of displays in radar systems, something we would now call human factors engineering," he says. "After I'd been there about six months, he made me a senior investigator."

When his mentor was offered a prestigious job overseas, he urged Brown to accelerate his work toward his degree so he could become the director of the Air Force contract. He got his Ph.D. in a year and nine months.

In 1954 Brown became head of the psychology division of the Aviation Medical Acceleration Laboratory at the Naval Air Development Center. At the same time, he served as an assistant professor of physiology at the University of Pennsylvania. Five years later, he became a full-time member of the medical school faculty at Penn; he was named director of the graduate training program in physiology in 1962.

"These were exciting times," he recalls. "As a member of the staff at the Aviation Medical Acceleration Laboratory, I was involved with astronauts like John Glenn and Neil Armstrong, providing them with an understanding of what it would be like to perform under high-acceleration forces. At Penn, most of my work was on the physiology of the visual system and the human senses. I wrote seven chapters on that subject in a major textbook on physiology."

In 1964 Brown joined Kansas State University, where the academic vice president convinced him to accept the post of graduate dean. "Six months later," he says, "I succeeded him when he accepted a more prestigious post." In 1969 Brown left Kansas to become a research professor at the Center for Visual Science at the University of Rochester; he later became director of the center.

In 1978 he was named president of the University of South Florida, which had been founded just 22 years earlier. His energies were directed toward the continued development of an institution that grew from 23,000 to 34,000 students (becoming the second largest university in Florida) during his tenure.

While serving as president of the University of South Florida from 1978 to 1988, Brown held appointments as professor of psychology in the college of arts and sciences, and as professor of ophthalmology and professor of physiology in the college of medicine. After relinquishing the presidency, he accepted a joint appointment in the colleges of engineering and medicine with the additional appointment of professor of industrial engineering.

In 1989 he was named director of the Human Factors Division of the university's Center for Urban Transportation Research. In the fall of 1992, following his retirement from the university, he was called back by the college of engineering to head a committee for the creation of a marine engineering research center. The following year he took on the responsibilities of interim director of the Center for Microelectronics Research, the job he held when he was called to WPI.

Brown met his wife, Catharine, while they were both students at Temple University. They were married in 1948, and the following year she received her bachelor's degree and he his master's. When their youngest child started school, she developed her own career. She earned a master's in psychology at the University of Rochester, did research at Xerox, and then became an assistant professor at Rochester Institute of Technology. The Browns have three grown children.

—ROGER N. PERRY JR. '45

Perry is senior writer for Quest, *WPI's development newsletter. A version of this article originally appeared in that publication.*

"These were exciting times. I was involved with astronauts like John Glenn and Neil Armstrong, providing them with an understanding of what it would be like to perform under high-acceleration forces."

Hail and Farewell

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campus, the investigation of educational use of new technologies seems to have stagnated. We have remained, essentially, a chalkboard culture."

One of Brown's hopes, when he arrived at WPI last fall, was to begin to change that culture. His enthusiasm for using new technology to improve the educational process began in the 1970s. Between 1978 and 1988, he served on a committee of the American Association of State Colleges and Universities that looked at communication technology in education; he served as vice chairman of the committee from 1986 to 1987. From 1979 to 1990, he was a member of the Educational Telecommunications Committee of the National Association of State Universities and Land Grant Colleges, a group he chaired from 1984 to 1985.

Brown's interest in educational technology was also fueled by the work of emeritus professor Kenneth Scott '48, who created WPI's Instructional Media Center in the 1960s as a service to WPI faculty members and students who wanted to create instructional videotapes. "Ken was a pioneer," Brown says. "I brought the dean of engineering at the University of South Florida up to meet Ken and see what he had accomplished some years back. That was part of the foundation for the creation of state-of-the-art studio classrooms at U.S.F. Recently, I sent Pennie Turgeon '91, who is the current director of the IMC, down to learn about those classrooms, which her predecessor helped inspire."

To jump-start the process at WPI, Brown named a committee of faculty members, students and administrators interested in new computer and telecommunications equipment in education. The committee met throughout the academic year and began to draft a model for a new approach to teaching using high technology. In addition, a conference on new educational technologies, open to the 10 institutions of the Colleges of Worcester Consortium, will be held at WPI in October.

"The process was, perhaps, inching along before I came," Brown says, "and now it is moving a bit faster. But the credit has to go to the faculty members who so enthusiastically joined the committee. I've had almost no input into the committee's discussions, nor does the committee need any input from me, except to know that it has my blessing and my support. They have done a marvelous job."

The work of the committee was, of course, just one element of a busy academic year, a year that saw the Institute welcome its largest class of freshmen ever, continue to hone its plans for a campus center, nearly complete the $8.75 million renovation and expansion of Higgins Laboratories, develop two new additions to the undergraduate program (the minor and the concentration), appoint new department heads in biology and biotechnology, management, and physics, reorganize the senior administration, spin off the Center for High Performance Computing as an independent corporation, celebrate the 20th anniversary of WPI's first off-campus project center in Washington, D.C., win approval from the Worcester City Council to turn West Street into a pedestrian mall, and elect a new president (see page 4).

Another important event in 1994-95 was the 50th Reunion of the Class of 1945, which includes many graduates Brown knew when he was a student. "I came to know many of those people very well," he says. "I played soccer with them, enjoyed activities with them. And there we all were together again after 50 years. That was very exciting. That may just have been the highlight of the year for me."

With the year now over, Brown is looking ahead to his third retirement. "I retired as president of the University of South Florida in 1988," he says. "I decided to teach for a few years after that, and I did some research and had some graduate students working for me until 1992, when I finally did retire. Katie and I were going to take the following summer off and just relax, but the university wanted me to teach statistics for engineers, the toughest course in the college of engineering. Being able to teach that pretty well convinced me I hadn't yet started down the road to senility."

He soon found himself helping set up a center for marine research and, later, acting as director for a center on microelectronics research after the center director left abruptly, an assignment that he was still engaged in when WPI called. Will his next retirement be as active as his previous ones? "Retirement to me is being able to do what you want to do," he says. "My wife says, 'Yes, but what you think you want to do at any given moment has locked you in for a year here or there.' So I am going to try to avoid getting tied too tightly to anything that's going to constrain our ability to travel and do things that will be fun for both of us.

"This has been a wonderful experience for me. I've enjoyed these nine months very much, and I'm glad that I had this chance to serve an institution that means a great deal to me. I've had the privilege of working with a community made up of people who are impressive, clearly exceptional people who are dedicated to the process of teaching and education. I have, perhaps, helped them by indicating my enthusiasm for the kinds of things they were willing to do, and by giving them my support to go ahead and do those things. People have been wonderfully complimentary about what I've done. Well, I'm not sure I've done that much, except to be a facilitator, a catalyst to keep things going."

"The university wanted me to teach statistics for engineers, the toughest course in the college of engineering. Being able to teach that pretty well convinced me I hadn't yet started down the road to senility."

The Stuff Dreams Are Made Of

Just two years out of college, Peter Travers is creating visual effects for major Hollywood films. His digital artwork enhanced *Crimson Tide*, and now he's using his computer to part the Red Sea.

By Ruth Trask

Following in the tradition of classic submarine films, *Crimson Tide*, this summer's blockbuster thriller starring Denzel Washington and Gene Hackman, has plenty of murky undersea action and frothy torpedo wakes. But thanks to the marvels of modern computer animation, the bubbles that percolate through *Crimson Tide* are some of the most realistic ever seen on film. Much of that realism is due to the ingenuity of Peter Travers '93, a software animator with Dream Quest Images in Simi Valley, Calif.

The focus of *Crimson Tide* is the missile sub U.S.S. *Alabama*, which is dispatched to the former Soviet Union after an ex-general takes over missile silos in eastern Russia. Among the film's action sequences is a tension-filled game of cat and mouse with a Soviet Akula-class attack submarine.

In the 90 special effects shots created for the movie by Dream Quest Images, the goal was to make the deep underwater scenes as believable and as unrelievedly tense as possible, Travers says. The company, founded in 1979, is a leading creator of visual effects for films, television shows and commercials. Its capabilities include computer animation, optical and digital compositing, digital image manipulation, motion-control photography and stop-motion animation.

Dream Quest's earliest work was for such science fiction films as *Escape From New York* and *Blade Runner*. More recently it created effects for *The Mask*, *Toys* and *The Secret Garden*. The company's digital visual effects helped the makers of *The Crow* complete the film after its star, Brandon Lee, was accidentally killed during filming. DQI's digital effects for the science fiction thriller *Total Recall* and the stunning underwater work it did for the film *The Abyss* won Academy Awards for special visual effects.

How did Travers, who is still on the sunny side of 25, manage to rise so fast in the heady world of

motion picture special effects? "You could say it all started while I was a student at WPI," he replies. "I discovered that I liked writing software and creating computer graphics while I was a work-study student at WPI's Instructional Media Center. And in my senior year I saw Steven Spielberg's *Jurassic Park*, which made a huge impression on me because the special effects were worked into the live action so naturally. Following

graduation, I had several job interviews, but nothing seemed creative enough."

Eventually, Travers enrolled at the Vancouver Film School in Canada, where he took a computer graphics course. He stayed only two months, though, because there were more students than computers and he could rarely find a free workstation. But something good came out of the experience. While doing research for a report about the use of computer graphics by major engineering companies, he contacted Wave Front, a forward-looking company in Santa Barbara, Calif., that makes software for high-end computer graphics.

"I never published the report," Travers says, "but Wave Front liked my work and offered me an internship and the opportunity to generate programs of my own. I didn't make any money, but I gained valuable experience. While following up on the problems Wave Front customers called in on the company's hotline, I learned how to develop software. I even helped create a brand new software program called Dynamation."

Dynamation, he explains, is based on the principles of physics and incorporates many equations that describe the way objects move and react to physical forces. The software enables animators to create movement that looks natural and smooth. The sequences generated with Dynamation are in sharp contrast to the less realistic motion generated with stop-motion animation, which has been the primary animation technique used in films since the early days of the movie industry.

"At Wave Front we developed a new technique for Dynamation that makes certain special effects, such as clouds, mists and bubbles, look more natural," he says. "The technique uses swirling particles, rather than stop-motion, to render the effects." The new technique has already been used to generate effects for a host of films, including *Star Trek: Generations*, *Star Gate*, *Last Action Hero* and *Apollo 13*. Travers also used it in the work he did for *Crimson Tide*.

While interning with Wave Front, Travers free-lanced on weekends to make ends meet. One animation sequence he created during this period using the Dynamation software was snapped up by the Fox Television Network, which now uses it as its main on-air logo. Before long his talent and experience won him a well-paying job in DQI's Digital Department, known throughout the film industry as the "techno-wizards."

"DQI was interested in my Dynamation program," Travers says, "because it is less costly to use than traditional digital animation programs. It also delivers 3-D realism directly to film." *Crimson Tide* was his first assignment for DQI.

Hollywood Pictures enlisted DQI to create scenes of huge submarines gliding through the deep sea, torpedoes speeding toward their targets, and a Russian sub imploding. Many sequences were filmed with eight highly detailed submarine models, ranging in length from 4 feet to 24 feet. The torpedoes were 6-foot-long working models.

The torpedo models, traveling along guide wires, were filmed in a large swimming pool with its walls painted black and the water filled with tempura paint particles to make it suitably murky. The submarine models, attached to posts that traveled along tracks or suspended by wires from a computer-controlled gantry, were shot on a smoke-filled soundstage. The dense smoke created the illusion that the models were in water.

Many of the live-action sequences required enhancement by the DQI Digital Department, Travers says, and that is where his talents and experience came into play. For many shots, for example, it was necessary to digitally paint out guide wires or other support hardware. But certain effects required the digital animators to render objects completely from whole cloth. For

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The Stuff Dreams Are Made Of

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example, the two-mile-long antenna that the *Alabama* deploys at one point in the film and the countermeasures the sub releases into the water to draw away the Russian torpedoes were created entirely through computer animation, work in which Travers was directly involved.

The techno-wizards also helped conjure up several torpedoes. The models looked realistic as long as they were traveling in a straight line along guide wires, Travers says. But a number of scenes called for the weapons to make sudden turns as they hunted enemy subs or chased after the countermeasures. In the film, the torpedoes that perform these tricks were completely computer generated by Travers and others at DQI.

Also created with the help of computer graphics, including Travers' Dynamation software, were the bubbles churned up by the torpedoes, countermeasures and underwater explosions, as well as the wakes created by objects as they moved through the water. These digital effects had to be seamlessly merged with the footage shot in the water and the smoke-filled stage. To do this, Travers and the other DQI digital experts used special compositing techniques that blended the computer-generated effects with a digitized version of the film. "We had to simulate and carefully time every torpedo turn and bubble to make it fit properly into the action of each scene," he says.

Digital enhancement also played a role in the most challenging sequence DQI created for *Crimson Tide:* the underwater explosion-implosion of an Akula submarine. Three 23-foot models of the sub were constructed from thin lead sheeting covering an aluminum skeleton. Inside were six large, evacuated jars. To implode the models, explosive charges were set off, shattering the jars and creating a powerful vacuum. Computer-generated bubbles helped enhance the real maelstrom kicked up by this effect.

Now that *Crimson Tide* is at your neighborhood theater, Travers has moved on to a new project—one of biblical proportions. He is helping DQI create digital special effects for *Moses*, a film that has Ben Kingsley in the title role. The film, produced by Turner Broadcasting System, will be shown on cable television in the U.S. next Easter and in movie theaters elsewhere around the world. "At the moment," Travers says, "we're trying to digitally part the Red Sea."

And when Travers says "we," he means it personally. He recently lured his brother, Michael, a Tufts University graduate, into joining him on DQI's techno-wizard team. "We enjoy working our engineering backgrounds into the development of software for special effects," he says. "We're in on the ground floor of an expanding—and exhilarating—industry."

Great Expectations

(Continued from page 11)

King that he doesn't care if Walter learns much in school, as long as what he does learn is learned "thoroughly, and without confusion or distaste." Another letter, from 1861, tells of Dickens' bathing habits: "I use (probably), as much cold water as anyone living, and have taken a daily shower bath these twenty years." There is also a fine letter of Dec. 16, 1842, to the noted artist and illustrator George Cruikshank, who illustrated Dickens' *Sketches by Boz* and *Oliver Twist.*

The Dickens letters are of great value, but they are not the only manuscripts in the Fellman collection. The gift includes an impressive set of autograph letters from a variety of Dickens' contemporaries, including writers, artists, scientists and statesmen. John Forster, Augustus Egg, Octavian Blewitt, George Cruikshank, Sir Robert Peel, Lord John Russell, Michael Faraday, Jeremy Bentham, William Harrison Ainsworth, William Godwin and Edward Bulwer-Lytton are among those represented.

Perhaps the most notable item in the entire collection—certainly the item Robert Fellman himself prizes most highly—is the unique "council attendance book" for the Guild of Literature and Art. This book records (by signature) those attending meetings of the council between June 12, 1854, and Dec. 7, 1896. It includes the signature of Charles Dickens more than 30 times, including two instances where Fellman suggests Dickens may have been "in his cups." A few of the many other notables attending meetings (and signing the book) were Dickens' first biographer, John Forster, Dickens' friend Wilkie Collins, who wrote the first English detective mysteries, *The Moonstone* and *The Woman in White*, and John Tenniel, the illustrator of Lewis Carroll's *Alice in Wonderland* and *Through the Looking Glass.* Dickens' eldest son, Charley, attended many meetings, signing his name as "Charles Dickens, Junior"; interestingly, the first time he attended after his father's death on June 7, 1870, he signed as "Charles Dickens."

The Fellman collection contains a wealth of fascinating historical and critical works that will be useful to those doing research on Dickens' world. Among these are dozens of books about Dickens' life and times, hundreds of books about his fiction, generous sets of works by such contemporary novelists as Thackeray, Jerrold, Bulwer-Lytton, Ainsworth and Washington Irving, and complete runs of two journals devoted to Dickens: *The Dickensian*, established in 1905, and *Dickens Quarterly* (formerly *Dickens Studies Newsletter*), established in 1970. Such resources as the Pilgrim edition of Dickens' letters (in seven volumes), the *Penny Cyclopedia* (a treasure trove of arcane Victoriana), and *Heads of the People* (a collection of

amusing Victorian caricatures) can now be used, and enjoyed, by scholars and students alike.

Robert Fellman did not amass his collection for the sole use of Dickens experts. He wanted his materials to be used by all those who love Dickens, and the terms of his gift specify that members of the Dickens Fellowship, an international group organized nearly a century ago, be invited to use the collection. (Fellman has served as the honorable secretary of the Palo Alto branch of the Dickens Fellowship, and several WPI faculty members, including myself, Professor Laura J. Menides and communications instructor Barbara McCarthy, are active members of the Worcester branch.)

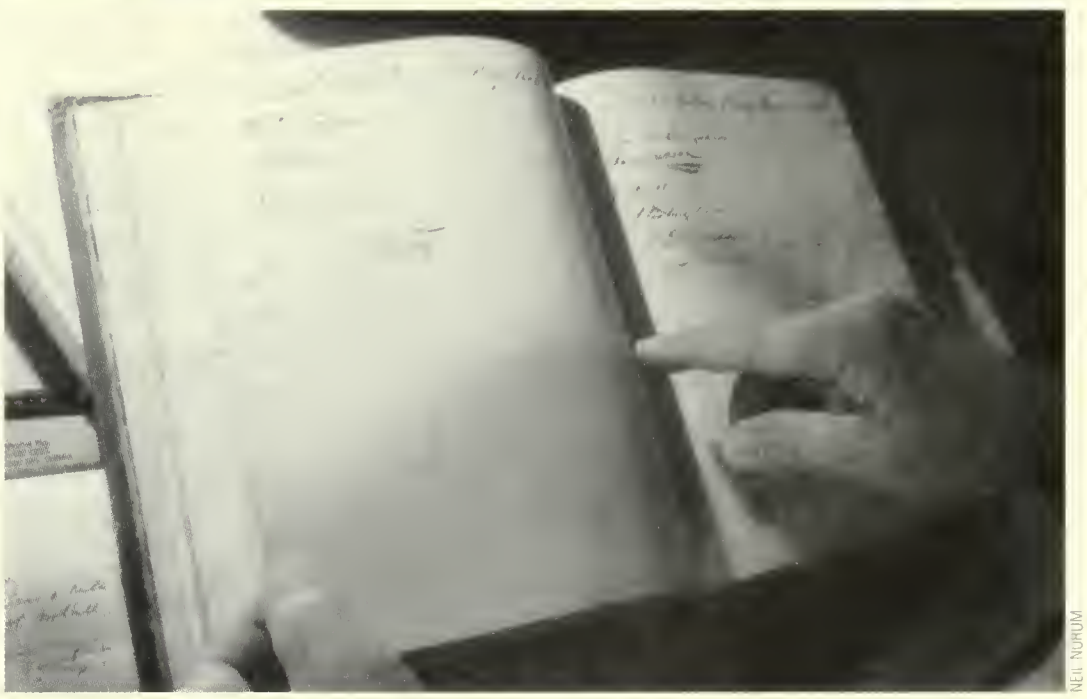
The Fellman collection includes many examples of the best 19th-century book illustrations, some fine rare bindings, and a most valuable 1817 example of fore-edge painting (a technique whereby a design is actually painted on the edges of leaves of the book, with the painting being revealed only when the pages are fanned in a particular way). Many of the most visually arresting items in the collection are works of art; the collection includes more than 40 matted and framed prints, paintings and drawings, and dozens of porcelain objects, several of them Royal Doulton plates and ceramic figures. A number of the art works are original pieces; of particular note is a color sketch for *Our Mutual Friend* by Dickens' original illustrator for that work, Marcus Stone.

Since Fellman wants his collection to be used and enjoyed, WPI is making arrangements with the management of Mechanics Hall, the building on Main Street in Worcester where Dickens spoke in 1868, to display some of the works of art in its "Dickens Room." Dickens came to Worcester twice. The first time he did not speak formally, but did take the time to submit to a phrenological examination. One of the foremost practitioners of that 19th-century pseudoscience examined the bumps on Dickens' skull and wrote a report interpreting his findings. The report is now one of the treasures of Worcester's American Antiquarian Society. Dickens slept in the home of Governor John Davis at 89 Lincoln Street in Worcester on Feb. 6, 1842, and left Worcester the next morning, on his 30th birthday.

Dickens didn't return to Worcester for more than 26 years; he came back to America only in the last years of his career, when he undertook a "Farewell Tour" of public readings. He came to Worcester for the second and last time, performing in Mechanics Hall on the night of March 23, 1868 (just eight months before WPI opened its doors). The enthusiastic crowd of more than 1,500 paid $2 each—Dickens' flat fee throughout the United States—to hear Dickens perform his readings (really dramatic interpretations) adapted from *A Christmas Carol* and *The Pickwick Papers.* Mechanics Hall still proudly displays a lectern Dickens is said to have used at this performance (although the author is known to have traveled with a special desk he often used for his dramatic readings).

While some of the items in this extraordinary collection (particularly the two- and three-dimensional art works) will likely be made available on extended loan to Mechanics Hall, the bulk of the collection will be permanently housed in WPI's Gordon Library. When it is completed, the Robert D. Fellman Dickens Room will contain

NEIL NORUM



NEIL NORUM

the collection and all the services necessary—including comfortable chairs and work tables—for WPI students and faculty, community members, and visiting scholars (including, of course, any members of the Dickens Fellowship) to use the collection. "We need to see that this valuable collection is protected, but we also want to ensure that all members of the WPI community have access to the materials they need," says Lora Brueck, archivist and special collections librarian, who will have the greatest responsibility for overseeing use of the Fellman Collection.

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Fellman shows off an example of fore-edge painting from his collection, top, and reviews the signatures of many well-known Victorian writers and artists (including Dickens) in the "council attendance book" for the Guild of Literature and Art.

A Love for "Bits and Pieces"

The Story of the Man Behind the Fellman Collection

Robert Fellman and Charles Dickens became good friends when Fellman was just 13. On a trip to the high school library in the small town of Red Lake Falls, Minn., where Fellman was born, he decided to check out a book with the curious title, *The Posthumous Papers of the Pickwick Club*, one of Dickens' earliest works.

Fellman was attracted by the Victorian author's humor, his sense of character, and his uncanny ability to draw a reader into his world. "He's a novelist who, when you read, is sitting on your shoulder. You can't get rid of him," he once told a newspaper reporter.

His love for Dickens' writing continued as he went on to study chemistry at the University of Minnesota Institute of Technology, where he earned a bachelor's degree in 1944. (He later received a master of science in chemistry at the University of Southern California and did additional graduate work in the discipline at the University of London and Stanford University.)

In 1958 he joined the faculty of the newly founded Foothill College in Los Altos Hills, Calif., where he served as chairman of the Department of Physical Sciences and Mathematics and was an instructor of chemistry and physical science until his recent retirement. His interest in Dickens remained that of a devoted fan until the early 1960s, when he took a sabbatical year in London.

While Fellman was in England, a friend in the London theater gave him a set of original early 20th-century watercolor illustrations of Dickens characters. The gift made him curious about the many illustrators who interpreted Dickens' large cast of colorful characters over the years. He began reading everything he could find on the subject, and as his knowledge grew he became interested in collecting Dickens illustrations.

In time, this fascination led to a love of all things Dickensian, and he began to amass a first-rate collection of books by and about the author, as well as artifacts and memorabilia related to Dickens. "You get a little knowledge, and with the help of serendipity, start looking for other things," he says. "One day you wake up and discover you're a collector."

Having caught the collecting bug, Fellman began looking for ways to expand his holdings. After returning from England, he placed an ad in a local paper looking for other collectors of Dickens memorabilia. He was contacted by a woman who owned a set of leaded-paned bookcases. When he went to see them, he decided that the charming house where they were located was just the spot for his collection. He bought the house a few days later.

Over time Fellman's Palo Alto home filled with the products of his collecting, with every room a gallery for illustrations, posters, letters —even a framed check signed by the author. An entire wall of shelves was filled with his collection of printed pieces. He reserved the most significant and attractive items for the knotty pine-paneled room he called the "Victorian Room."

In 1973 Fellman decided to share his collection with the local community. He organized an exhibit, "Dickens and His Illustrators,"at Foothill College and included many of the rare books and artworks he owned. The following year he began to share his extensive knowledge of Dickens, as well. He organized a summer course at Foothill College titled "Charles Dickens: The Man and His Work," which he taught for many years. The popular course included two field trips to visit large collections of Dickens-related material: one at Stanford University, and one in Fellman's home. In fact, he says, many of the items in his collection were the result of his desire to have exciting things for "show and tell" with his students.

Along with the students in the first offering of his summer course, Fellman applied for and received a charter from the London-based Dickens Fellowship for a Palo Alto chapter of the society. Fellman was the chapter's first president and has, for many years, edited its newsletter. He is currently "honorable secretary."

Over the years, Fellman has often been asked what it is about Charles Dickens that has kept him exploring the author's life. He told a reporter some years back, "It was said very nicely by George Orwell: 'The genius of Dickens lies in his unnecessary details.' Being a chemist, I like bits and pieces of information."

Thanks to Fellman's devotion, endless curiosity, and great generosity, a remarkable collection of "bits and pieces" relating to the life and times of one of the world's greatest writers is now available for "show and tell" in the Worcester area, where it will enrich students and scholars for generations to come.

— Michael Dorsey

Over the years, Fellman's Palo Alto, Calif., home became filled with the items in his collection, including figurines, like this Royal Doulton interpretation of Mr. Pickwick.

NEIL NORUM

NEIL NORUM

Great Expectations

(Continued from page 27)

Though dozens of boxes of materials have already arrived in Worcester, it will be some time before the entire collection is available for use. It will take months—perhaps even a year or more—before everything arrives from Fellman's Palo Alto home, and it will also take time for the items to be catalogued and shelved. Still, the bulk of the material should be in place by late 1996, when WPI will sponsor a Dickens Symposium to highlight the Robert D. Fellman Dickens Collection. The symposium will offer a variety of scholars and teachers a chance to present and discuss their research on Dickens, and will afford participants the opportunity to explore the riches of the new collection.

"We look forward to welcoming Dickens experts from New England, and from across the nation," says Gordon Library Director Helen Shuster. The symposium, under my direction, will be held Sept. 20-22, 1996. The Dickens Society of America, of which I am both secretary and treasurer, will hold its business meeting at the conference; it will be the first time the business meeting of the Dickens Society will be held independently of the Modern Language Association since the founding of the society in 1970.

Fellman, a retired teacher of Dickens whose academic preparation was primarily in the area of chemistry (see story, page 28), found WPI to be an ideal site for his beloved collection. He was aware that Worcester, the second largest city in New England, lacked a first-rate Dickens collection. He was also attracted by the innovative nature of the WPI Plan, which prepares technologically aware humanists and culturally sophisticated and flexible engineers for satisfying careers and, more important, for the continual explorations, adaptations, excitements and surprises of life.

Fellman also said he liked WPI's "hands-on" approach to teaching. He assembled the collection with the idea that the materials should be used, and he was particularly delighted that the first boxes of materials (arriving in time for Dickens' 183rd birthday on Feb. 7, 1995) contained items WPI students could use right away. For example, in The English Novel, a seminar I taught last winter, I was able to show students a bound volume of *All The Year Round* that included the first serial installments of *Great Expectations*, the Dickens novel the class was studying at the time.

Subsequently, I have been able to utilize the collection for the purposes of scholarly research, as well. Examining original volumes of *Bentley's Miscellany* in preparation for a review of a new edition of Dickens' journalism allowed me to detect a number of flaws in that new edition, which the editors may be able to avoid in future volumes. Just as important, I've been able to guide students in using the collection for their own work. This spring David A. Boulanger '96 was able to consult a rare work on Dickens' *Pickwick Papers* as part of his research for his Humanities Sufficiency project. This fine paper, growing out of Boulanger's WPI course work, explored the illustrations by Robert Seymour, Robert Buss and Hablot K. Browne that accompanied the original serial installments of Dickens' richly comic first novel.

Thanks to Fellman's generosity in establishing the Fellman Dickens Collection, many more students will be able to explore the richness of Victorian culture right here in Worcester. "Because of the breadth of this collection, students interested in history, literature and the arts will have a unique resource at their fingertips," says Lee Fontanella, chair of the Humanities and Arts Department. "This collection will be of value, not just to Dickensians, but to the whole community."

About the Author

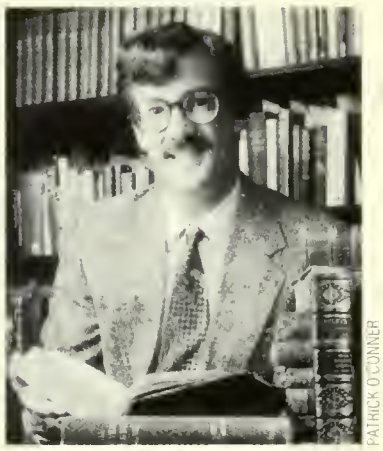
Joel J. Brattin, associate professor of English in the Department of Humanities and Arts, came to the Institute in 1990. He is currently secretary and treasurer of the Dickens Society of America, which has some 600 members.

Brattin received an A.B. in English literature from the University of Michigan and went on to earn a doctorate in English at Stanford. His doctoral dissertation treats the manuscripts of four of Dickens' last novels. Before joining WPI, he was a teaching administrator at Stanford, the academic coordinator for the Dickens Project at the University of California, Santa Cruz, associate editor of *The Essential Carlyle*, and assistant professor of English at Missouri Southern State College.

Over the years he has published many articles and reviews on Dickens and other 19th-century British writers in *Dickens Quarterly*, *The Dickensian*, *Dickens Studies Annual* and *Nineteenth-Century Prose*. His first book, an annotated bibliography of Dickens' *Our Mutual Friend*, was published in 1985. Today he serves on the editorial board of *Nineteenth-Century Prose* and is an advisory editor for and contributor to the *Companion to Charles Dickens* volume forthcoming from Oxford University Press.

Brattin is also an authority on the music of the late rock guitarist Jimi Hendrix and has explored the artist's work through numerous reviews and articles. He has also served as a consultant for a variety of Hendrix projects, including books and audio and video releases.

Brattin first met Robert Fellman when he was working on his Ph.D. at Stanford, and he occasionally used Fellman's collection in his scholarship. "I was immediately taken by Bob's love for Dickens, his deep knowledge of the Victorian milieu, and his generosity and delight in sharing his collection with all the members of the local Dickens Fellowship," he says.



PATRICK O'CONNER

Projects Aim to "Save the World"

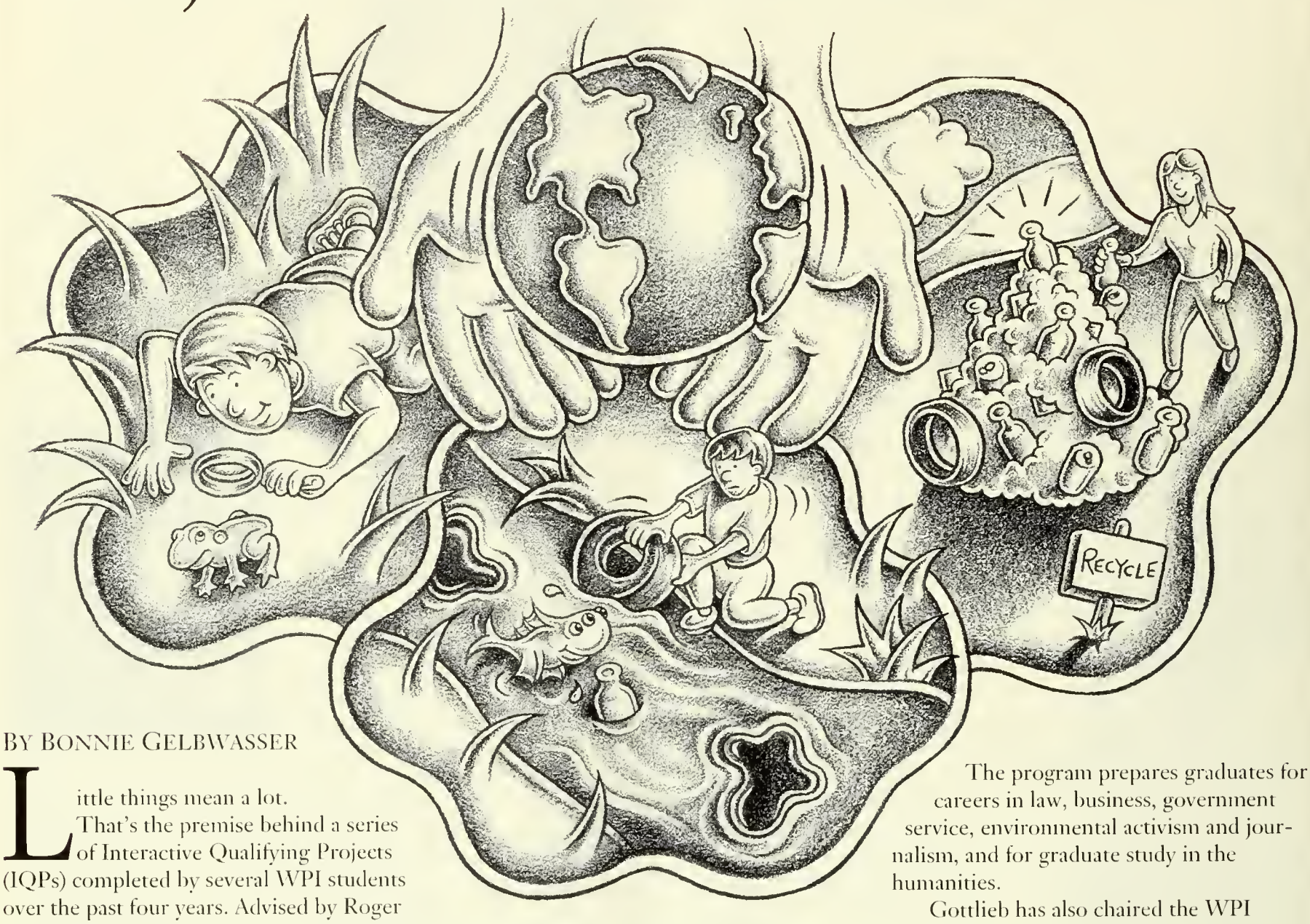


ILLUSTRATION BY GREG VALLEY

BY BONNIE GELBWASSER

Little things mean a lot.
That's the premise behind a series of Interactive Qualifying Projects (IQPs) completed by several WPI students over the past four years. Advised by Roger S. Gottlieb, professor of philosophy in the Humanities and Arts Department, the projects aim to "save the world" in small but significant ways.

"The idea for the IQPs came out of my own interest in the environment and my belief in the central importance of combining our understanding of the environment with attempts to improve our relationship to it," Gottlieb says. "The projects seek to bring technology and society into the most perfect harmony for the good of everyone."

Each project spans three academic terms. "The first term is dedicated to studying broad issues in environmental theory and to finding a particular area of action," says Gottlieb. "During the second term, students research their action area and begin the concrete activities necessary to complete the project. These activities continue during the third term, culminating in an extensive written report."

Since 1992, Gottlieb has advised 15 students who've completed five "Save the World" projects. This fall, Alexander Frazier '96, Mario Miele '96 and Keith Bosse '96 will map the tree cover at the Wachusett Meadows Sanctuary in Princeton, Mass. Their results will be placed in a database at the sanctuary and the students will relate the tree cover at Wachusett to the general conditions of forests in New England. Also this fall, Tom Tanimoto '97 and Mika Newton '97 will develop a course on environmental literature in which poems and stories will be used to "open up the emotions that nature arouses in man" and to "teach people to love the world in which they live."

Recently named the Paris Fletcher Distinguished Professor of Humanities at WPI, Gottlieb is the coordinator of WPI's Humanities/Environmental Studies curriculum. Students interested in humanistically oriented environmental studies can major in the humanities with concentrations in literature, philosophy and religion, or history.

The program prepares graduates for careers in law, business, government service, environmental activism and journalism, and for graduate study in the humanities.

Gottlieb has also chaired the WPI Campus Committee on Environmental Affairs, which has worked on a range of campus environmental issues, including the need to find ways to reduce paper use. He is on the steering committee of the Religion and Ecology section of the American Academy of Religion and is editor of *Capital, Nature, Socialism*, an international environmental journal.

He has written widely on social theory, the Holocaust, contemporary spirituality and environmental theory. Among his recent books are *Thinking the Unthinkable: Meanings of the Holocaust* and *Marxism 1844-1990: Origins, Betrayal, Rebirth*. He is the editor of *This Sacred Earth: Religion, Nature, Environment*, a survey of traditional religious myths, creation stories and conceptions of nature from Jewish, Christian, Native American, Indian, African, Chinese and indigenous texts and commentators. Contributors focus on religion in an age of environmental crisis.

During the second half of the 1995-96 academic year, he will be on sabbatical to complete *Holocaust and Ecocide*, an examination of three critical similarities between the Holocaust and humanity's current treatment of the environment. "The book," Gottlieb says, "will describe the despair that takes the form of a rejection of spiritual forces or meanings; the public despair that arises when the full scope of Jewish resistance is absent from public commemorations of the event; and the political despair prompted by the way humanity as a whole has created an environmental crisis that in some ways mimics the Holocaust on a global scale."

Here's a look at a few of the projects that have been completed through the "Save the World" program in recent years:

Saving the Watershed to Save the River

"We must start small and work up to the larger problems in order to save the world." Paul Beliveau '95, Michael Briggs '95, Robert O'Connell '95 and Michael Schulz '95 wrote those words in their IQP. The major work of the project was the creation of a brochure that explains how to preserve the water quality at Worcester's Broad Meadow Brook Wildlife Sanctuary. "This project is designed to find a way to involve the populace in something they can see and care about—something that is easy to do and yet accomplishes more than anyone can imagine," the students wrote.

The 277-acre Broad Meadow Brook Sanctuary is the largest urban wildlife sanctuary in New England. It is owned by the city, New England Power Co. and the Massachusetts Audubon Society. The society manages the oakwoods, fields, former pastures, streams, marshes and swamps for the owners, a consortium dedicated to wildlife habitat and nature education. Broad Meadow Brook itself is a tributary of the Blackstone River, which flows from Worcester to Providence, R.I., where it empties into Narragansett Bay. In Worcester, the river is fed, in large part, by storm drains running under the city. The river is currently so polluted it cannot be used for recreation.

In their project, Beliveau, Briggs, O'Connell and Schulz focused on nonpoint pollution (that which can't be traced to a specific location) in Broad Meadow Brook's 1,242-acre watershed. The watershed is bounded by Saint Vincent Hospital to the west, Granite Street to the east, Route 20 to the south, and Grafton Street to the north and extends well beyond the sanctuary's borders.

The students traced sewer lines that empty into the river back to their sources to determine where most of the pollution comes from and to identify problem areas for the city to target for cleanup. They also prepared a pamphlet that describes things people who live near the sanctuary can do to help improve the water quality of the brook and the ecosystem around it. They presented their findings at a community meeting in Worcester.

The pamphlet, which is available at the Broad Meadow Brook sanctuary, includes such suggestions as refraining from littering in the watershed; maintaining septic systems properly; following integrated pest management and organic gardening principles; correcting improper hook-ups to storm drains; and properly disposing of used motor oil.

"By cleaning up the watershed we are working with a small community on a small scale," the students conclude in their project report. "It is an attainable goal that could very well lead to the improvement of the Blackstone River."

Protecting All the World's Populations

In "Specieism, not Humanism!" Kimberley Aho '94 and Michelle West '94 studied the relationship between an ethic that says that only people have value, and the consequences of that ethic, which is the destruction of other species. "They proposed an alternative ethic," Gottlieb says, "a 'biocentric' ethic that says that all forms of life have value and that nature has an intention and a purpose of its own—it doesn't just depend on human beings."

The students examined population growth and the impact of such accompanying problems as the depletion of the rain forest and global warming on other species, "because population growth and the destruction of the rain forest are two key areas where you destroy habitat—and that is the most significant thing in destroying species," they wrote.

To learn firsthand the interrelationship of species and ecosystems, and about how the actions of human beings affect the fate of other species, the students gathered information for the Massachusetts Audubon Society's Herp Atlas Project, a database that documents the statewide distribution of reptiles and amphibians such as turtles, snakes, frogs, toads and salamanders. During several Sunday forays to vernal pools in the Broad Meadow Brook Wildlife Sanctuary, the students identified green frogs, red-back salamanders, snapping and painted turtles, bullfrogs, eastern garter snakes and northern water snakes.

They stressed the interrelationship between human and animal environments and the responsibility individuals must take for preserving that connection. "Focusing on saving individual species from universal extinction will not be effective unless the ecosystems they inhabit are preserved," they wrote. "Without the preservation of a wide variety of species, the entire ecology of the planet is doomed....While individuals may change their lifestyles and groups work for the benefit of the environment, true change for the better must come from changes in human society."

Recycling to Save Our Resources

There is a need for a long-term comprehensive program to break down the economic and political barriers that keep us from achieving a global society that practices sustainable development, including redistribution of wealth and closed-system recycling. That is the conclusion of an IQP completed by David Anderson '94, Arun Chawla '94, David O'Donnell '94, Kevin Roy '94 and Rachel Stratford '95, who say that the process of reusing products and conserving natural resources may be the best first step toward this vision.

"Recycling, in light of its recently increasing popularity, is an excellent choice to begin this process. Technology to achieve healthy recycling rates for the planet exists but needs legislative and economic help."

For their project, the students looked at the applications of existing recycling technology and evaluated the implications of recycling on waste reduction and energy conservation. "If new sources of energy are identified, if recycling efforts are maintained and/or strengthened, if energy efficiency is improved in the building, industrial, transportation and other sectors, and if political and economic factors are cooperative, a balance of human advancement and planet stability may be attained."

"The environmental crisis is a critical threat," Gottlieb says. "But it is also a critical opportunity to see the truth about how we have been living, to reassess what is truly important in our lives, and to make the changes that will make sense of ourselves, other people, future generations, and all the life around us. Recycling, these students have shown, can be a crucial part of those changes."

EDITOR'S NOTE: *After graduating from WPI, Alex Thorp went to work for an engineering firm specializing in water resource management. Finding the work unfulfilling and troubled by questions about his own place in what he saw as a too complicated and too commercial world, he set out on a personal quest that began with a trip across North America by bicycle. This is his story.*

Travels With Alex

BY ALEX THORP '92

On my cross-country trip, I discovered that traveling by bicycle has its advantages. First, it's cheap—only about $20 a day. Second, although the trip takes much longer than it would in a car, you get to see more of the landscape. And the exercise that bike-riding requires can have a bit of a mind-altering effect, as endorphins course through your brain and make you feel awake and alive.

Overall, the trip was fantastic. I'll never forget seeing antelope running at high speed through waist-high grasses, their black heads barely visible above the grass tops, or fog enshrouding the Rockies, the blue open sky contrasting sharply with the gold wheat fields of the west, and smoke and ash filling the sky from huge forest fires raging in the Northwest.

As I peddled through Washington state, nighthawks, their wings and backs striped in white, swooped down at me, then skirted off to prepare for another run. Common carp swam in layers along the shore of Lake Sakakewea in North Dakota. King Salmon ran up a river running north from Georgian Bay in southern Ontario, leaping over rocks and locks. In Minnesota, I saw endless fields of sunflowers, a shock to the eyes on a bright day. (On a cloudy day the sunflowers hold hands and gently bow their heads.)

And then there were the people. Everywhere I went there were thoughtful strangers eager to talk about almost any topic with a lone cyclist. I especially remember an old farmer with rich, dark hands who quietly reminisced about growing grapes, his life's work.

"I went into the woods because I wished to live deliberately, to front only the essential facts of life, and see if I could learn what it had to teach, and not, when I came to die, discover that I had not lived."

—HENRY DAVID THOREAU

In *Travels With Charley*, John Steinbeck wrote that in most of the towns he visited, people said they wanted to get away from where they were. I also found that to be true. A number of folks told me they longed to step outside the boundaries of their everyday lives. Many said they wished they'd done it years ago when they were young and free. They seemed curious about the unknown and frustrated in their attempts to make their lives more meaningful.

Some said they felt as if they were victims of overpowering outside forces—industry, big business, the government, the military, the media, commercialism. In a way, I suppose, these institutions, which we support, are reflections of ourselves, and we don't like it when we see greed, hatred and intolerance reflected in these social mirrors.

Along with the thought-provoking conversations and beautiful scenery, danger and pollution were always with me. Several motorists objected to my mode of travel; I had a lot of close calls, but no one ran into me. The roadsides across America were appalling, with McDonald's wrappers, crushed cans and tattered magazines strewn everywhere.

Despite the downside, I really enjoyed the trip. It helped me develop a confidence that I could manage anything, anywhere, on my own. I decided to leave the open road behind and settle, at least temporarily, where I could contribute to a local farming economy.

I was born in Norway, as was my mother, so it was natural that I look there. Through an organization called Atlantis, I contacted a woman who owns a medium-size dairy farm

Alex Thorp's bicycle trip included a transit of the Cascade Mountains in Washington State (opposite page) and stops in a myriad small towns across the U.S. and Canada. He followed up that adventure with four months on a farm in Norway, bottom.

on Gimsy Island, part of the Lofoten Islands, which are known around the world for their codfish.

That's how I came to spend four months working for Unni Hov. She has 28 cows on her farm, 16 of which are milked twice a day. My job was to feed and clean the animals, and to push their waste into the cellar of the barn. At first I was afraid of the cows, but by the time I left for home we had become friends. They responded most affectionately when taken care of (just like people do). I even started talking to them.

Each day, after I finished caring for the animals, I fixed broken machines, plowed snow and built things—all normal activities for a farmer. Although it was physically demanding, I enjoyed what I did. It was honest and necessary.

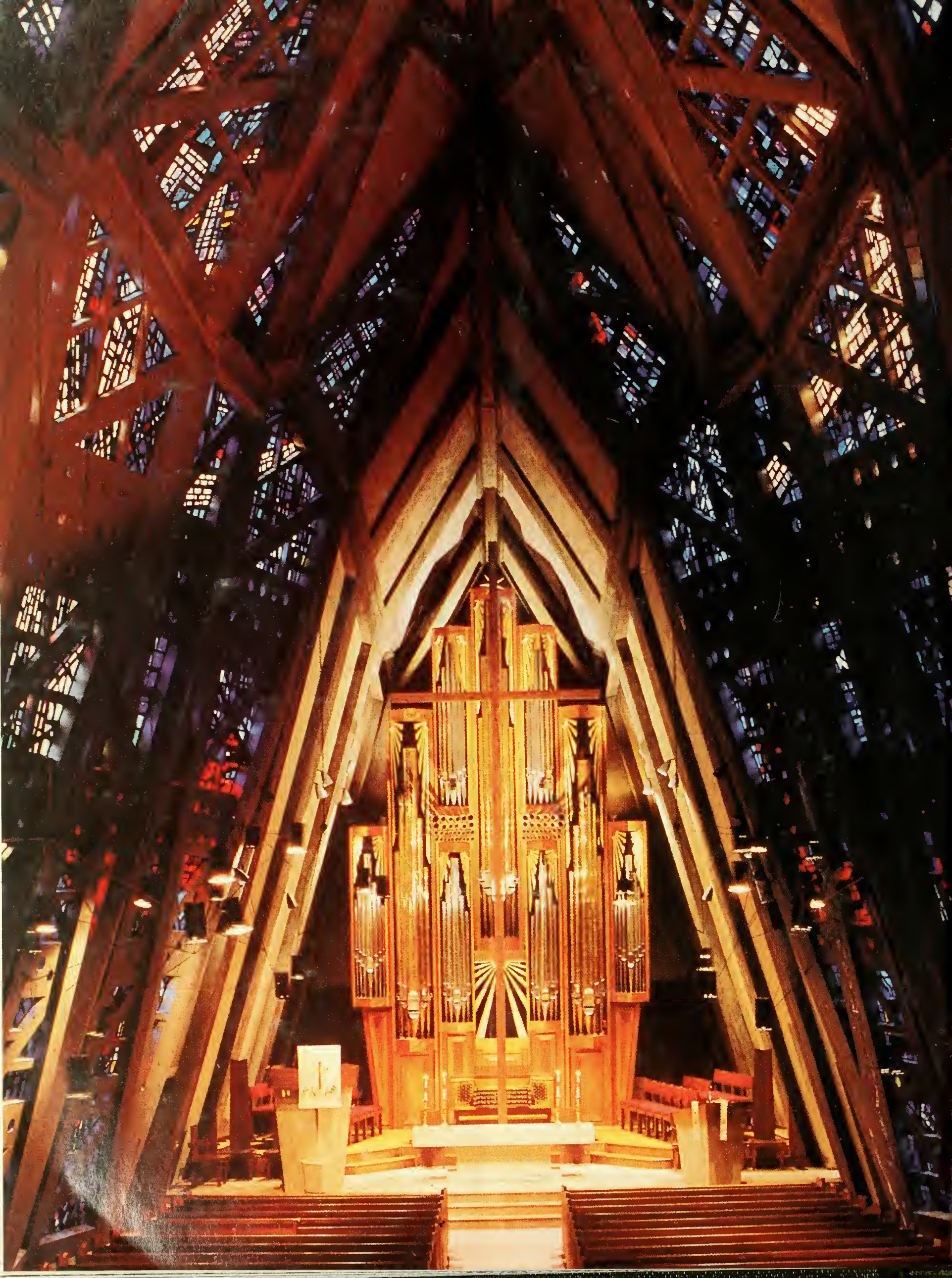
Occasionally, I milked the cows with a vacuum pump, even though I believe the relationship between farmer and cow is diminished by the use of such equipment. But the reality is that farms can support more cows and produce more milk since the introduction of the milking machine. Before World War II, most Norwegian farmers milked four or five cows by hand and stored the milk in a small tank cooled by mountain water. Today, for better or worse, the milk is stored in huge refrigerated tanks that are dependent on electricity.

While advances in technology have enabled farmers to produce more in a given amount of time, I believe that, in general, there are great costs—societal and ecological—involved in such a transformation. We are paying dearly for our practices. Using modern technology doesn't necessarily imply bad farming practices, but it does increase the risk of practicing in error.

Life on the farm wasn't dull. Although we lived far away from any population center, there were beautiful beaches and mountains where I could walk or ski. The local chorus was a wonderful outlet, through which I met other people living on the island. There was always time for reading, writing and conversation. Unni, I discovered, is an excellent cook. Almost every day she served delicious fresh fish, potatoes, carrots, and homemade breads and cakes. Her family visited her for Christmas and we had a great time eating, drinking and exchanging presents.

Even though Gimsy Island is north of the Arctic Circle, the climate is relatively mild—not unlike New England, though a bit windier. It was also extremely dark in the winter. I directly saw the sun only three times during a three-month span. If I wanted to take a hike at high noon I had to wear a headlamp. It seemed strange to see the sun rise in the mornings when I returned to Rhode Island in March 1995.

Bicycling across America and working on a Norwegian farm turned me on to real quality time—and to myself. I was able to see my country and countrymen up close and personal. I was able to share in a simpler life in a foreign land less affected by pollutants and crass commercialism. Both adventures enriched my past. I hope to build on both as I look to the future—a future that may well include life on a small farm where I can enjoy a society built around a locally based economy.



THE YEAR IN REVIEW ◆ WPI'S FISCAL PERFORMANCE IN FY95 ◆ AN HONOR ROLL OF DONORS

WPI JOURNAL

FALL 1995

Creating a New Vision for Technological Higher Education

Front Cover: Illustration by Fabio Deponte, White Pickets Studio. This Page: David M. Smith '96, a civil engineering major who plans to pursue a master's degree in fire protection engineering, conducts a demonstration in the new Fire Science Laboratory in the fully renovated and expanded Higgins Labs. See story, page 13. Photo by Vaughn Winchell.

Volume XCVIII, No. 4, Fall 1995

WPI Journal

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The Annual Report of the Institute

A Work in Progress: WPI and the Future of Technological Education

by Edward A. Parrish

In his first annual report message, WPI's 14th president looks at the changing landscape for technological education in the United States. As chairman of the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology, Parrish offers an insider's perspective on work under way by ABET and other organizations to define a new vision for the education of tomorrow's engineers and scientists. In that new vision, Parrish finds some familiar themes. The need to integrate the humanities into the technological curriculum; the need to help students develop teamwork and leadership skills and a global vision; the need to instill in students an appreciation for the societal consequences of their work—these are all integral elements of the WPI Plan, the innovative, project-based educational program WPI pioneered a quarter century ago. "In reengineering technological education, there is no better example to follow than that of WPI," Parrish concludes.

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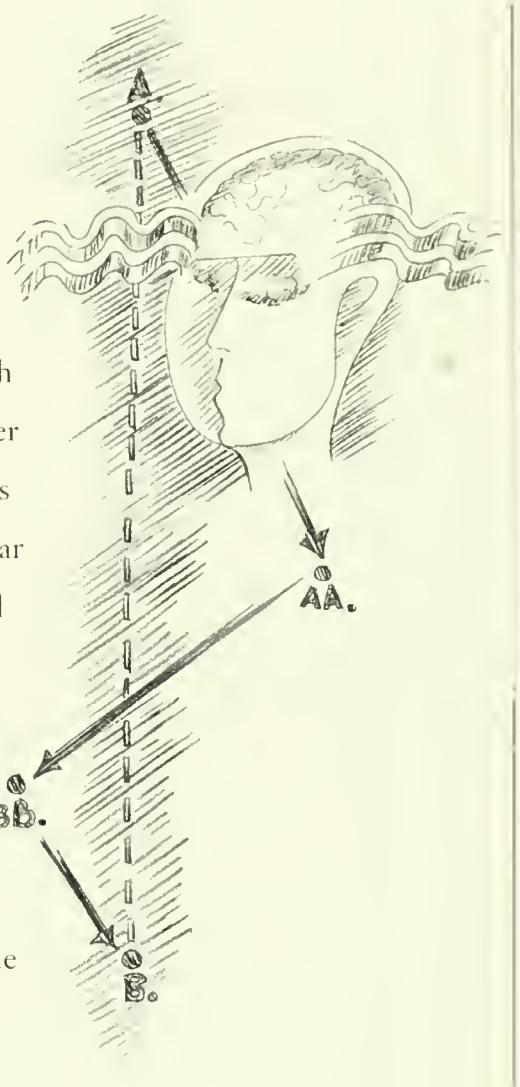

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Year in Review Remembering the events, acheivements and people of 1994-95, *by Michael Dorsey.* **Page 13**

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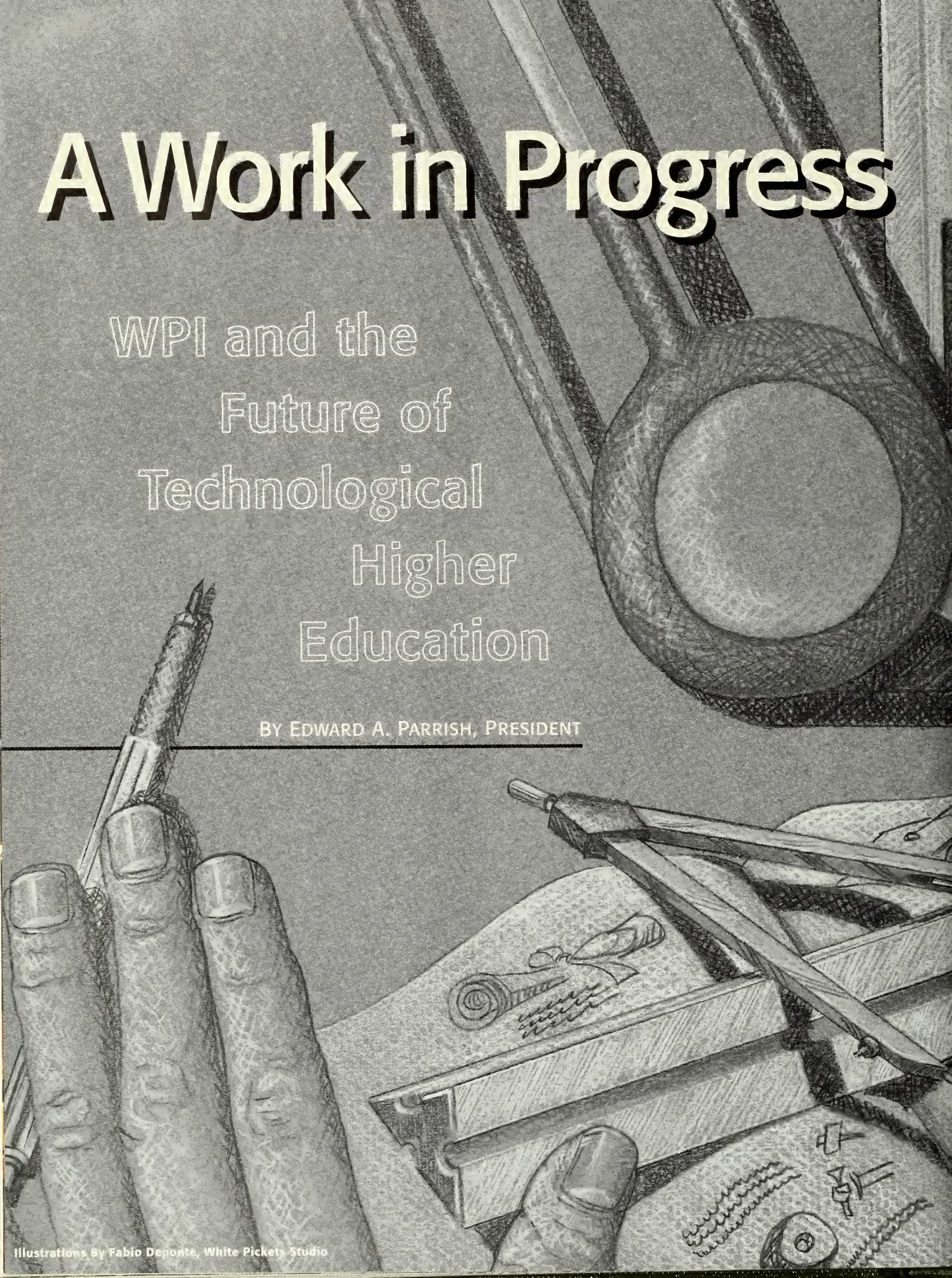
A Work in Progress

WPI and the Future of Technological Higher Education

By Edward A. Parrish, President



Illustrations by Fabio Deponte, White Pickets Studio

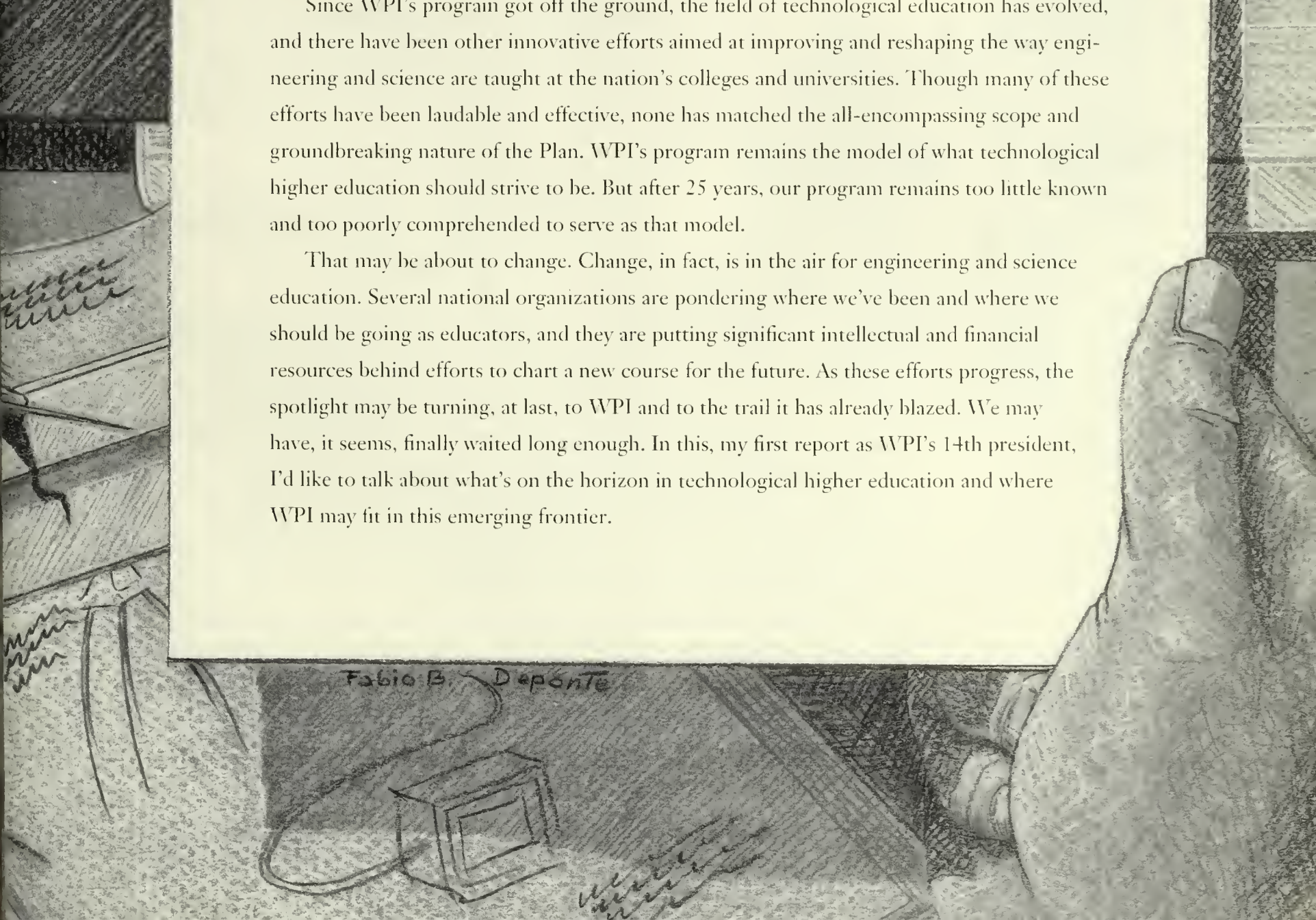
It's been said that *all things come to those who wait.*

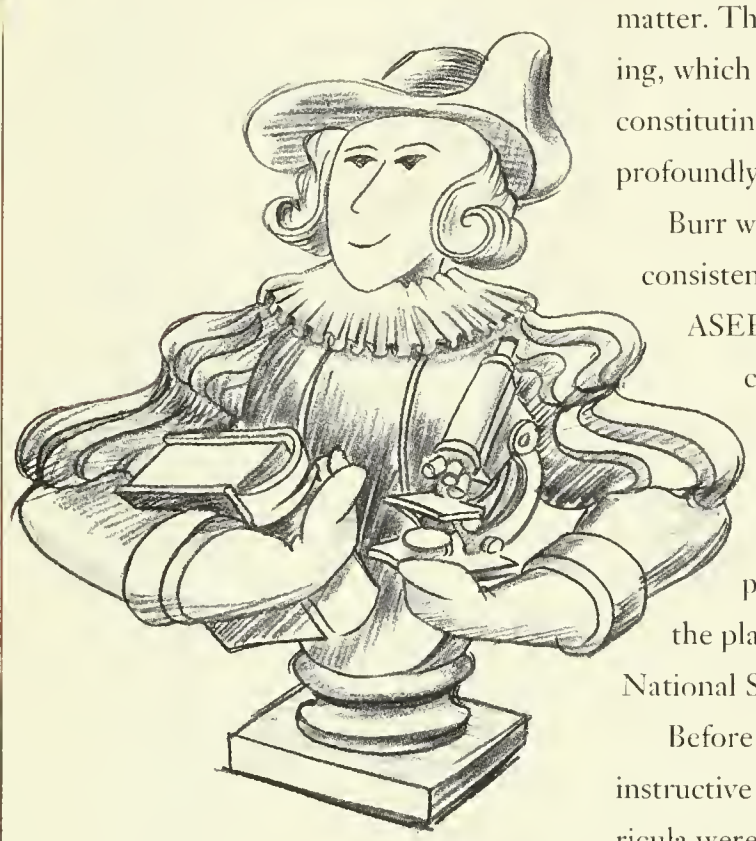
Well, WPI has been waiting for a quarter of a century for the world beyond its campus to fully understand and appreciate its remarkable undergraduate education program. Breaking boldly from the content-intensive, competitive curriculum that had long been the norm for technological universities, WPI in the early 1970s created a whole new way of preparing young men and women to become engineers, scientists and managers. It was an approach that emphasized content, to be sure, but one that also sought to instill in students the skills, attitudes and ways of viewing the world that would serve them well in their careers and lives.

The WPI Plan was truly an inspired and well-reasoned response to a real need in the field of technological education. What's more, all the evidence suggests that it has been highly effective in achieving its goal of educating a distinctly different type of technological professional—one who is well-prepared to thrive in today's team-oriented, project-based, quality-driven workplace; one who understands how to work in a global marketplace; one who's attuned to the social dimensions of science and technology. Those qualities are even more in demand by business and industry today than they were when the Plan began in the early 1970s.

Since WPI's program got off the ground, the field of technological education has evolved, and there have been other innovative efforts aimed at improving and reshaping the way engineering and science are taught at the nation's colleges and universities. Though many of these efforts have been laudable and effective, none has matched the all-encompassing scope and groundbreaking nature of the Plan. WPI's program remains the model of what technological higher education should strive to be. But after 25 years, our program remains too little known and too poorly comprehended to serve as that model.

That may be about to change. Change, in fact, is in the air for engineering and science education. Several national organizations are pondering where we've been and where we should be going as educators, and they are putting significant intellectual and financial resources behind efforts to chart a new course for the future. As these efforts progress, the spotlight may be turning, at last, to WPI and to the trail it has already blazed. We may have, it seems, finally waited long enough. In this, my first report as WPI's 14th president, I'd like to talk about what's on the horizon in technological higher education and where WPI may fit in this emerging frontier.





William Burr's "Ideal Engineering Education" — merging the liberal and the technical — 100 years later, it's still a guiding force.

Just over a century ago, at the first meeting of what is now the American Society for Engineering Education (ASEE), William H. Burr, professor of civil engineering at Columbia College School of Mines, gave a presentation titled "The Ideal Engineering Education." He emphasized two fundamental characteristics he believed should be part of such an education. The first was a broad, liberal education in philosophy and the arts that would serve to cultivate human qualities and enable engineers to interact well with people, as well as with matter. The second was a thorough training in the natural philosophy of engineering, which he said included the body of mathematical and scientific knowledge constituting the theory of engineering. He believed the second feature to be as profoundly practical as it is profoundly theoretical.

Burr was clearly ahead of his time. The framework he proposed is remarkably consistent with efforts under way by several prominent organizations, including ASEE itself, to reshape engineering education. There are some additional concerns that face modern engineering educators, of course, such as the need to attract more women and underrepresented minorities to the field, the need to place more emphasis on teamwork in the engineering curriculum, and the need to stress the global context in which the engineering profession is practiced today. But Burr's fundamentals are basic elements of the plans evolving from the work of ASEE, the National Research Council, the National Science Foundation and other groups.

Before looking at where technological education might be going, it may be instructive to consider where it has been. For much of this century, engineering curricula were highly practice-oriented. Students were trained in laboratories and shops using industrial-scale equipment and instrumentation. This was the approach that prepared the engineers who built the Panama Canal, the scientists and technologists of the National Advisory Committee for Aeronautics (NACA) who helped drive the early development of aviation, the men and women who created the first digital computers, and the visionaries—including WPI's own Robert Goddard '08—who launched the age of the rocket.

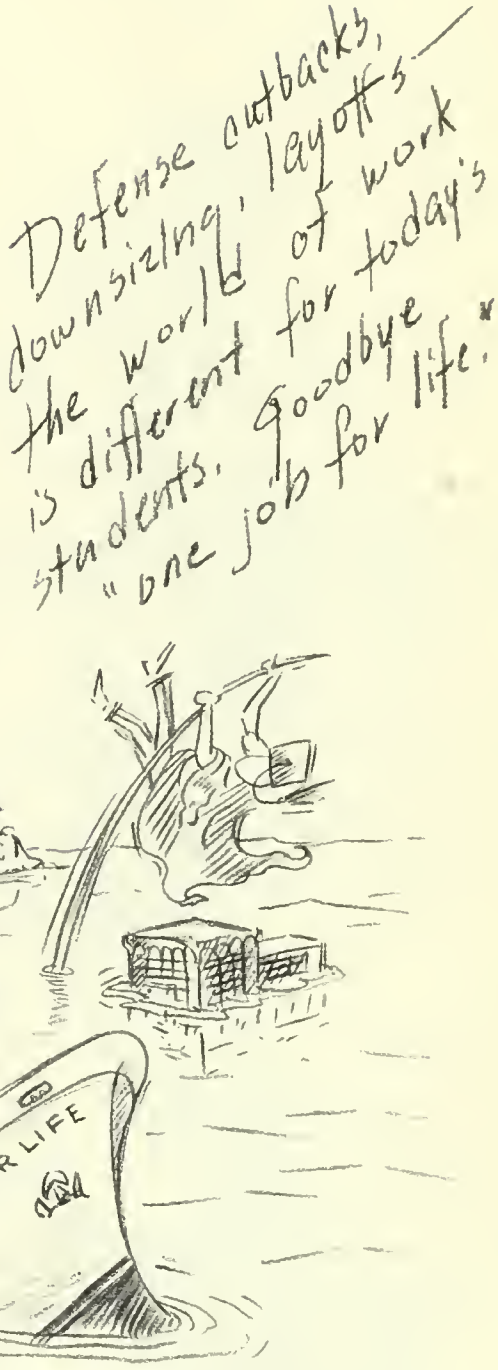
World War II had a tremendous impact on the development of technology and on the growth of the university-based research enterprise. The Manhattan Project and the invention of radar led policy makers to invest heavily in programs that generated a new category of institution—the research university. Vannevar Bush was instrumental in founding the National Science Foundation in 1950. Along with the Department of Defense and the Cold War, the NSF was a paramount force in the subsequent growth of research efforts in universities and in the creation of a varied array of partnerships between the academy and industry.

Like World War II, the launching of Sputnik I on Oct. 4, 1957, created in the U.S. a political will that led to the mobilization of science and engineering research on a massive scale. Recognizing the importance of space exploitation for civilian and military purposes, the federal government transformed NACA into the National Aeronautics and Space Administration (NASA) on Oct. 1, 1958. The agency has gone on to become a major player in the support of university research.

The combination of these factors created an environment that led engineering educators to place more emphasis on engineering science at the expense of engineering practice. Faculty reward structures emphasized discovery of new knowledge, rather than application of that knowledge, and the explosion of technology led to increasing complexity. Naturally, this complexity led to increasing specialization in the engineering profession, and this, in turn, fostered greater compartmentalization in the engineering curricula. Still, engineering education in this form has served the nation well for nearly 50 years.

The postwar era has witnessed a bewildering parade of technological achievements. Upon its 25th anniversary in 1989, the National Academy of Engineering asked its members what they considered to be the top 10 outstanding engineering achievements of that quarter century. They included the Apollo moon landings, the development of application satellites, the jumbo jet, computer-aided design and manufacturing, and genetic engineering. No. 3 on the list was the microprocessor, which has been at the center of so much of recent technological progress.

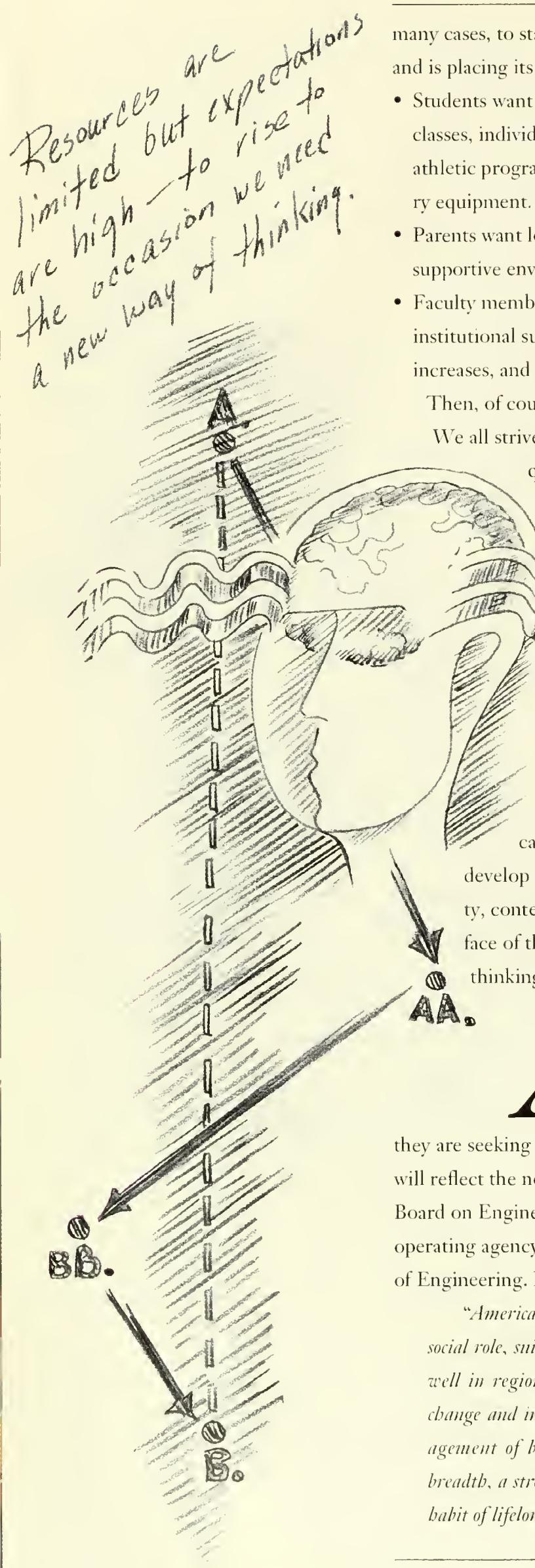
The forcing functions for many of the technological leaps of this century have been wars: two world wars and the Cold War, with several skirmishes thrown in for good measure. Thankfully, our current era of scientific and engineering progress is being driven not by a major war, but by the end of the Cold War. But this transition to peace has its own political, economic and social ramifications, and these factors have already had a tremendous impact on the engineering profession, as well as on technological education.



For example, the end of the Cold War has led to substantial reductions in the U.S. defense budget, a development that has had an impact on the budget of every federal agency. The reduction in defense spending has also affected the private sector. The resulting downsizing and reorganization of major corporations has caused massive layoffs and made technical careers less attractive to prospective students. We have also seen the end of the "one-job-for-life" paradigm.

Still, the shrinking of the U.S. defense infrastructure has done nothing to dampen the pace of technological change. In fact, new scientific and technological advances are appearing faster than ever, placing a premium on a broad education and lifelong learning for today's technologically oriented professionals. In part, this explosion of new knowledge is being driven by a rapidly developing global marketplace, which has fostered growing competition among the nations of the world.

Once again, technological higher education is expected to rise to the occasion. And, not surprisingly, at a time when federal spending for everything from research to financial aid has declined or, at best, remained flat, and when corporations and individuals have fewer dollars to invest in higher education, our universities are expected to do more with less and are subject to greater accountability than ever before—to students, to parents, to alumni, to employers, to government and, in



many cases, to state legislators. Each of these constituencies has its own expectations and is placing its own demands on our limited resources. For example:

- Students want access to high-quality residence halls and campus centers, small classes, individual attention from faculty members, broad arrays of academic and athletic programs to choose from, and access to the latest computers and laboratory equipment.
- Parents want low tuition, personal attention for their sons and daughters, a safe and supportive environment, and more financial aid.
- Faculty members want small classes, opportunities to teach their favorite courses, institutional support for their research interests, sabbatical leaves, regular salary increases, and pleasant physical surroundings.

Then, of course, there are the demands that universities place upon themselves. We all strive to assure continued financial stability, to attract and retain a high-quality faculty and staff, to provide sufficient resources to enable the faculty and staff to do their jobs, to provide financial aid packages sufficient to assure a diverse student population—both ethnically and economically, to provide a high quality of life for students, to maintain a high level of information technology, and to maintain and develop the physical plant.

Clearly, expectations are high, but resources are limited. If you add all this up, it quickly becomes apparent that the equation will not balance—we can't have everything we want. In many ways, institutions are faced with the same challenges that have caused such upheaval in corporate America. To prosper, we must develop our marketplace and provide what our customers need: a high-quality, contemporary education at reasonable cost. Accomplishing that in the face of the social and economic pressures we face will require a new way of thinking and a new approach to technological education.

A number of groups have taken on this challenge. They are taking stock of how universities should prepare scientists and engineers to compete in this new world order, and they are seeking to assure the development of a technological educational system that will reflect the needs of the United States in the 21st century. One such group is the Board on Engineering Education of the National Research Council, the principal operating agency of the National Academy of Sciences and the National Academy of Engineering. Here is how the board has articulated its vision for the future:

> *"American engineering education will have found new priorities and a new social role, suited to the post-Cold War world. Engineering graduates will compete well in regional as well as global markets characterized by rapid technological change and intense competition. They will assume more central roles in the management of both industry and government and will have greater intellectual breadth, a stronger sense of social responsibility, a penchant for collaboration, and a habit of lifelong learning."*

The board also specified what it believes to be the attributes of a suitable technological curriculum: "1) it includes all the necessary fundamentals and excludes redundant material; 2) it integrates the fundamentals well with design; 3) it is practice-oriented; 4) it emphasizes teamwork as well as individual effort; 5) it instills a sense of the social and business context and the rapidly changing, globally competitive nature of today's engineering; 6) it is broad enough and liberal enough to prepare students for possible entry into nonengineering professions; and 7) it instills a knowledge of how to learn and a desire to learn."

In 1990 the National Science Foundation stepped into the fray by funding the Engineering Education Coalitions. Some 60 institutions, organized into eight groups and backed by $100 million in federal funds, are now working toward the following objective:

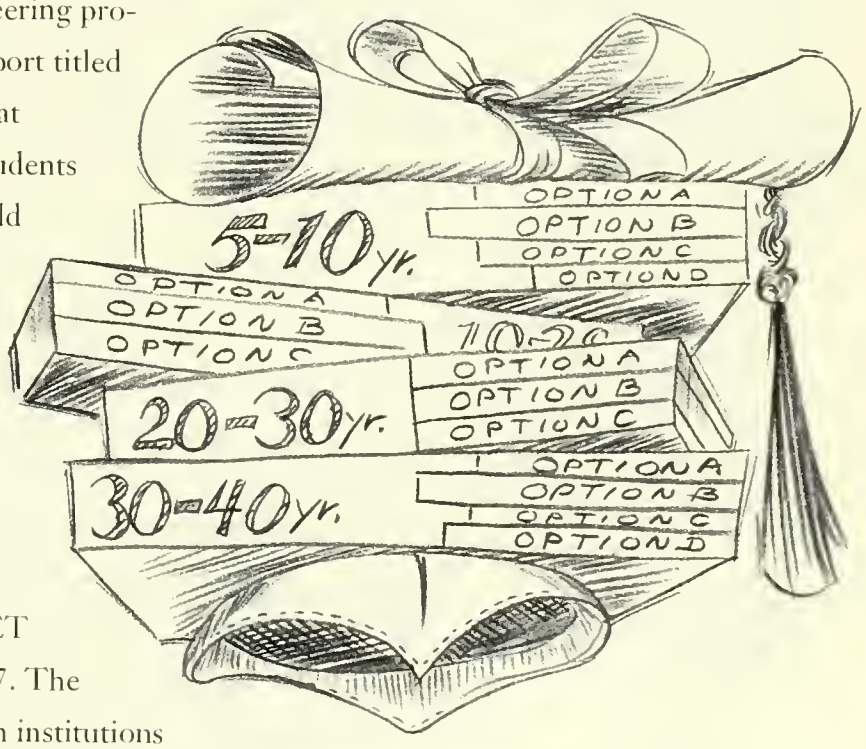
> *The goal of the Coalitions is to stimulate the creation of comprehensive, systemic models for reform of undergraduate engineering education. To accomplish this reform, the Coalitions are developing tested alternative education tools, curricula, and delivery systems. By applying these tools, they also hope to increase the successful participation of under-represented groups in engineering education and to improve linkages to K-12 schools. Through cross-coalition collaboration, they plan to develop significant intellectual exchange and resource links among undergraduate engineering programs.*

The Accreditation Board for Engineering and Technology (ABET) is also attempting to help shift the paradigm. ABET has made many positive changes to engineering accreditation over the past few years, but most of them have dealt with improving underlying processes, not with establishing new criteria. In May 1994 the NSF sponsored the ABET Engineering Criteria Workshop, attended by representatives from educational institutions, industry and ABET-participating societies. The resulting report called for revolutionary changes to the criteria for accreditation.

The report provided a foundation for more than a year of deliberations by the criteria committee of the Engineering Accreditation Commission (EAC), the group within ABET that accredits the nation's undergraduate engineering programs. The criteria committee presented to the full EAC a report titled *ABET Engineering Criteria 2000*, which included a proposal that engineering programs be measured against outcomes (what students learn) rather than process (what courses are taught). This would be a significant change from the old "bean-counting" days of engineering accreditation.

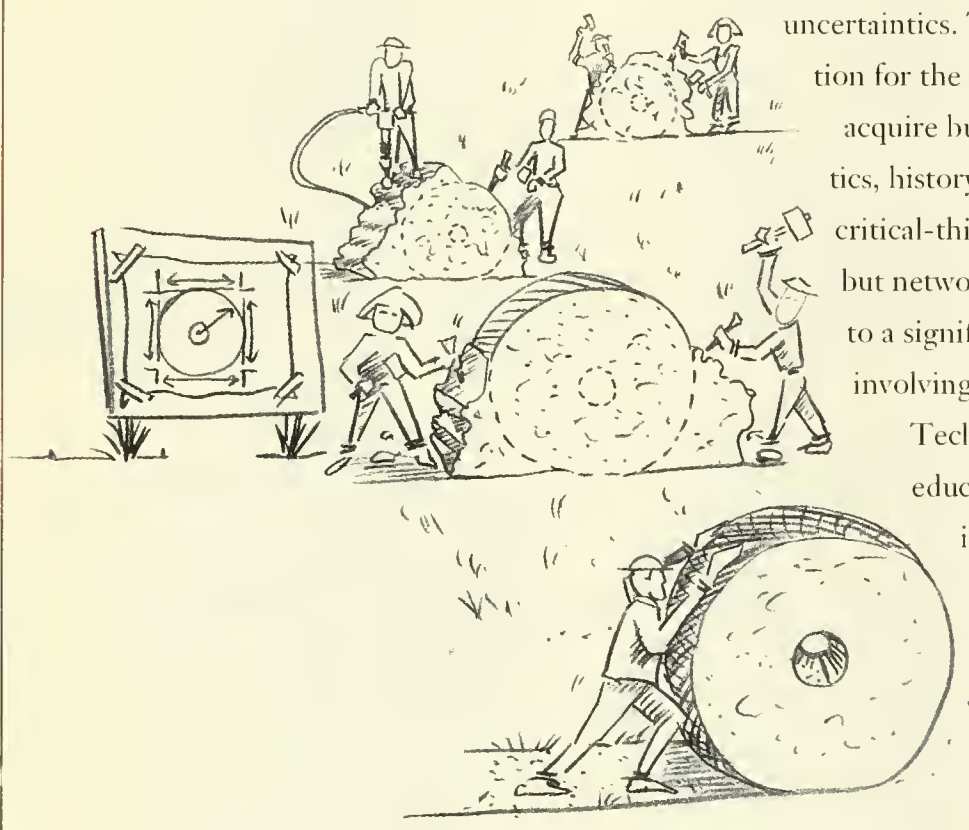
The EAC adopted the recommendation unanimously during its annual meeting this summer. As newly installed chairman of the EAC, I presented the recommendation to the full ABET board in November. The board approved it unanimously, and the new criteria will now enter a two-year public comment period. After suitable revisions by the EAC, the ABET board will consider final adoption at its annual meeting in 1997. The EAC has proposed a three-year transition period, during which institutions may choose which set of criteria will be applied to their programs.

the new vision: give students the versatility to cope with the changing demands of a 40-year career.



The theme that links all of these efforts is that the principal challenge facing engineering education is to provide graduates with the intellectual versatility they will need to cope with rapid technological changes in the course of a 40-year career. To develop the full human potential, universities must provide an integrative curriculum across the institution involving mathematics, science, the liberal arts, business and engineering. We must educate (students learning to learn) as well as train (students learning to do) while instilling in our students a passion for sustainable, lifelong learning.

Such systemic changes require intra- and interuniversity cooperation and resource sharing. We need to continue our movement from analysis to synthesis, from fragmentation and compartmentalization to integration, from individual to team effort, from just problem solving to problem formulation with uncertainties. This will result in a new "liberal arts" engineering education for the 21st century. Our budding scientists and engineers must acquire business skills and must understand and appreciate politics, history and culture, and they must develop their creativity and critical-thinking abilities. They must be not only computer literate, but network compatible. The shift from heavy emphasis on theory to a significant practice component implies actual project work involving some form of industry collaboration.



Technological programs must not only produce broadly educated engineers and scientists, but graduates who can go into areas like health care, law, banking and finance, insurance, teaching at the elementary and secondary levels, and so on. All of our graduates must learn how to listen as well as how to communicate effectively in oral, written and graphical forms. And they must be able to work in teams within a global context.

NSF, NRC, ABET: They're reshaping technological education. But are they reinventing the wheel WPI built 25 years ago?

Sometimes the best way to accomplish a difficult task is to follow the example of someone who has already done it. In re-engineering technological education, there is no better example to follow than that of WPI. The Institute is already meeting the "new" expectations outlined by the National Research Council, and has been doing so for 25 years. We are already preparing our students for the technological demands they will face in the next century. Our graduates understand and appreciate politics, history and culture, and they know how to think critically. They are used to working in teams, exerting leadership, and applying their creativity to the solutions of complex problems in a global setting. The WPI graduates I have spoken with during my brief tenure here have all expressed how important these factors have been to their own success.

After a quarter century of experience with innovative approaches to engineering education, WPI has much to share with the institutions involved in the eight NSF consortia. In fact, WPI will be asking the NSF to fund a major study of the WPI Plan and its graduates, a study we believe will demonstrate to the world at large the benefits of this time-tested approach to technological education. The Plan should

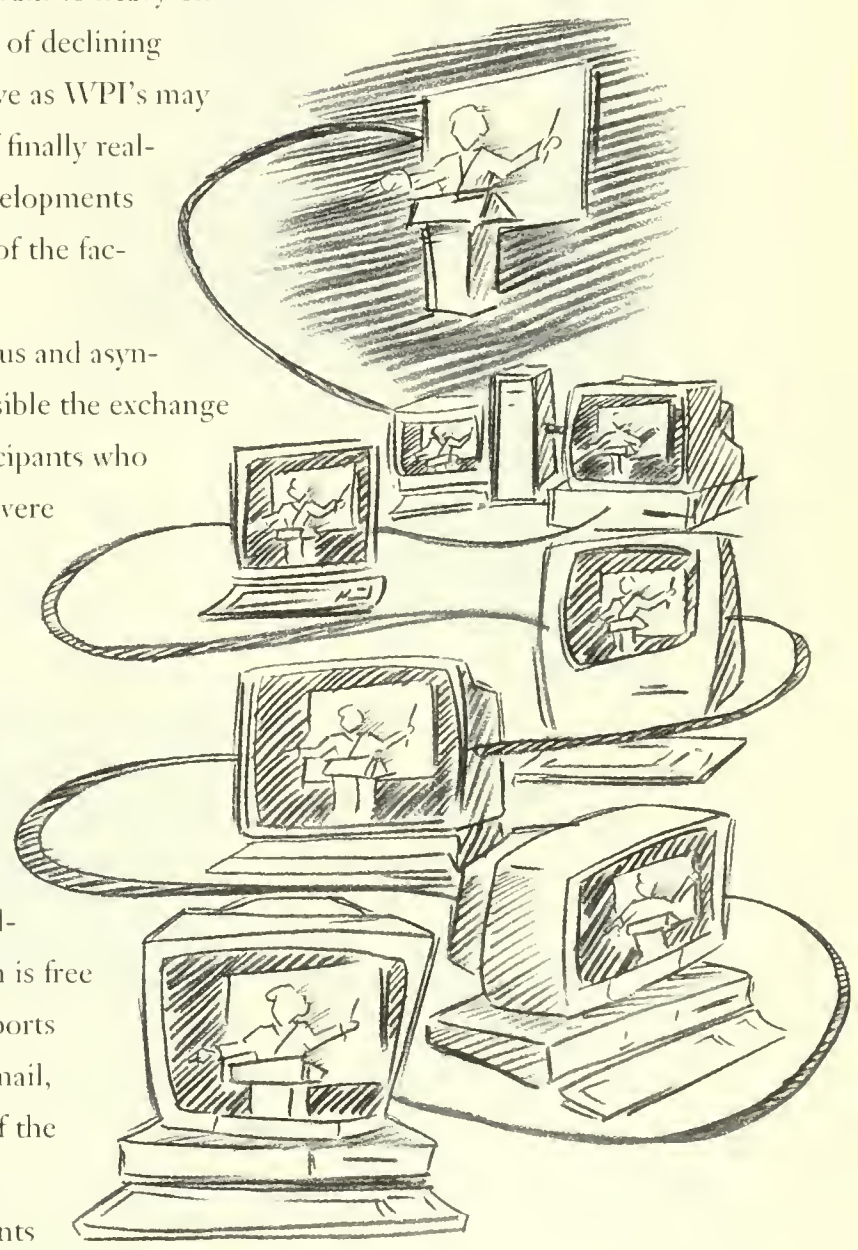
also be an excellent test bed for the new outcomes-oriented approach to engineering accreditation that has been proposed by ABET, for our program is already decidedly outcomes-oriented.

The Plan, the latest manifestation of WPI's 130-year-old Two Towers Tradition, with its balance between theory and practice, accomplishes much of what a modern technological education should. Through the Sufficiency, one of WPI's three required projects, students develop an understanding of the humanities. The Interactive Qualifying Project (IQP) emphasizes the need to learn about how technology impacts society. The Major Qualifying Project (MQP) challenges students to solve problems typical of those to be encountered in their professional disciplines.

Taken together, these three projects emphasize that technological professionals must learn not only to create and manage technology, but to assess and manage the social and human consequences of that technology. WPI's global projects program, the most ambitious and effective international program in technological education in the country, enables students to become immersed in a different culture and to learn about teamwork in a global context.

Clearly, the WPI Plan is an excellent model for other institutions to follow, but it does have its limitations. Perhaps the most significant is the demands it places on WPI's resources. Delivering a program so heavy on integration, teamwork and project work is labor intensive. In a time of declining resources and heavy faculty workloads, a program as faculty-intensive as WPI's may be a difficult sell. Fortunately, it appears that we are on the verge of finally realizing the promise of information technology in education. New developments in computers and communications should help leverage the efforts of the faculty and make it easier for students to help other students learn.

The Plan demands much of the faculty. But a new generation of information technology may leverage their efforts.

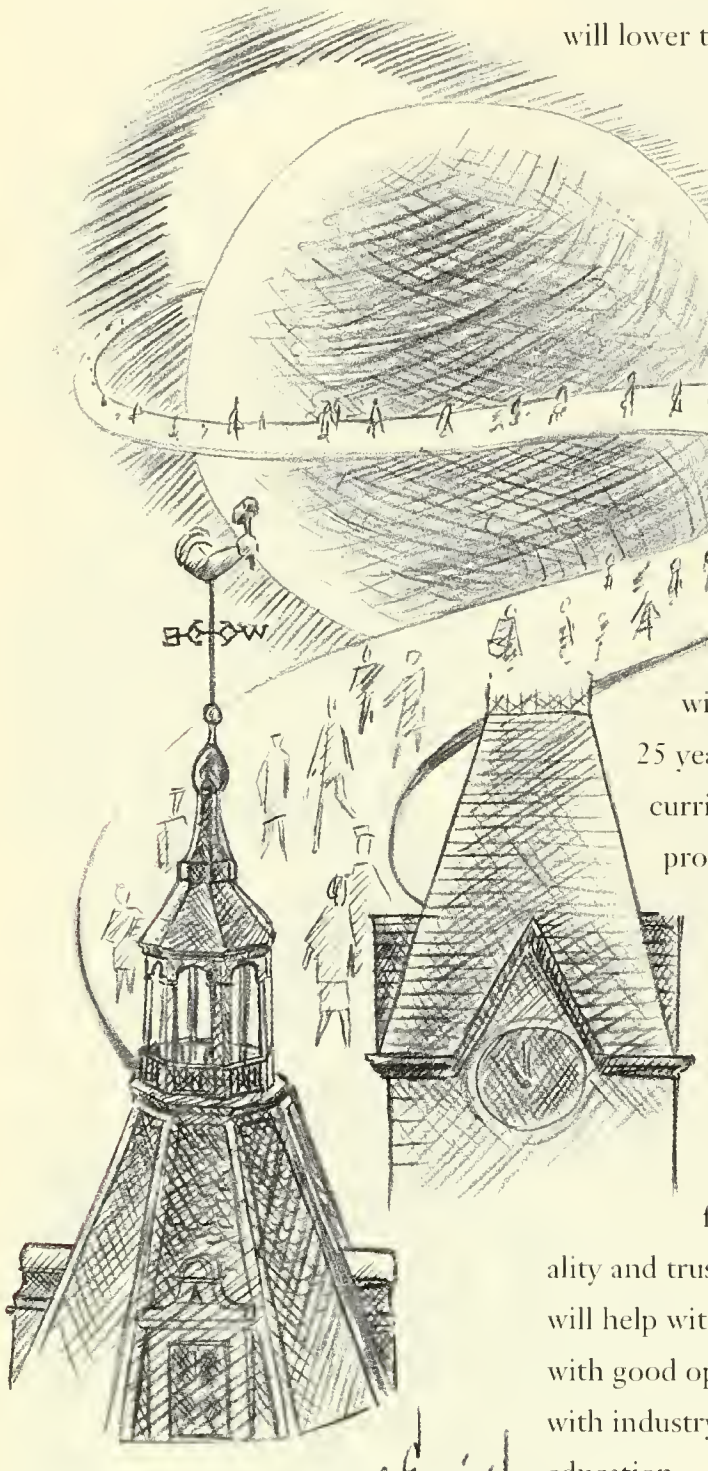


The technology that will make this possible includes synchronous and asynchronous communication. Synchronous communication makes possible the exchange of multiple streams of data (audio, video, data) in real time, so participants who are located at some distance from each other can interact as if they were in the same room. Asynchronous communication, which includes things like Internet newsgroups, computer bulletin board systems and remote whiteboard conferencing, lets participants interact when they are separated in both place and time. We can also create virtual or distributed classrooms by delivering "lectures" (either live or from videotapes and CD-ROMs) over computer networks.

The rapidly evolving World Wide Web portion of the Internet is developing into an excellent delivery mechanism. It is widely available, it supports multimedia, and a browser such as Netscape (which is free to educational institutions) can act as a universal front end as it supports protocols for hypertext, sound, animation, movies, file transfers, e-mail, chat, news groups, and interactive communications. The ubiquity of the Web makes it an excellent medium for networked learning that can help extend peer-to-peer interactions to faculty members and students at other universities.

The adoption of technologies like these will require that faculty members become coaches, or guides, rather than omniscient teachers. It will involve greater use of teamwork. It will encourage the replacement of yellowed lecture notes with highly dynamic course content. In addition to the added excitement and versatility all of this should bring to our learning environment, there is also the great possibility it will lower the cost of education.

Information technology alone may not guarantee a successful paradigm shift, however. Engineering educators must also become engaged in understanding how students learn. As the various learning styles of our students are better understood, the value of educational technology is likely to increase more rapidly through our ability to design learning environments that adapt to individual learning styles.



A promising road ahead for technological education - it may lead, at last, to recognition for WPI's Pioneering Plan.

The work now under way to establish a new direction for technological higher education leaves me feeling optimistic about the future of this profession. I am equally optimistic about the role that WPI will play in helping to shape that new direction. WPI's pioneering efforts 25 years ago to build—from the ground up—an innovative, project-based curriculum, and its admirable work since then to enhance and expand that program, particularly into the area of global technological education, place the Institute at the forefront of the movement to shape the future of engineering and science pedagogy. I think the time has come for WPI's achievement to be fully recognized and emulated.

The Plan was just one of the positive qualities about WPI that attracted me to this remarkable institution. I was also impressed by its reputation for quality programs; by its bright students and its innovative faculty; by the fact that it is a compact community that reflects collegiality and trust; by its long history and legacy, both of which provide credibility and will help with student recruiting and fund raising; by its location in a high-tech area with good opportunities for collaboration and development of true partnerships with industry; and by the fact that it is at the leading edge of global technological education.

These qualities provide an excellent foundation for future achievement and continued excellence. Like all of higher education today, WPI faces important challenges, some of which I have outlined in this report. But we have the necessary ingredients, not the least of which are the outstanding people who make up the WPI community, to face those challenges and enter the 21st century a stronger, more dynamic and, most certainly, better known institution. I hope it is evident that I am excited about what I have found here at WPI. I welcome your ideas and your interest as we set about the work that lies ahead.

EDITOR'S NOTE: This message is based on Engineering Education for a Changing Engineering Profession, *an address by Edward Parrish, delivered during the Union College Bicentennial Celebration in Schenectady, N.Y., on Oct. 14, 1995.*

FINANCIAL SUMMARY

By Stephen J. Hebert '66

Vice President for Administration, Treasurer, and Secretary of the Corporation

I'm pleased to report on the financial condition of Worcester Polytechnic Institute at the close of business on June 30, 1995 (FY 95). These results have been audited and endorsed by the firm of Coopers & Lybrand.

WPI enjoyed another successful year financially, although the difficulty in developing a balanced budget points, once again, to the pressures of financial aid, the dependency on tuition income, and the need to structure WPI for the future so that the university can invest in emerging technologies or disciplines of interest as appropriate to the times.

The overall operating budget for the year finished with a favorable variance of $156,000 on a base budget of approximately $67 million. Credit should be given to all the members of the faculty and staff for their efforts to bring this budget in on balance and to accept the financial realities of these challenging times.

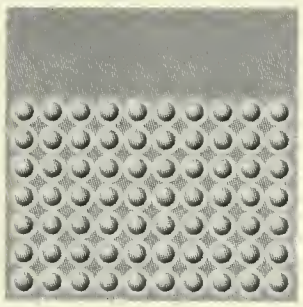
During FY 95, per the vote of the Board of Trustees, an authorized expenditure of $600,000 was dedicated to the development of interface disciplines. This $600,000 produced a budgeted deficit, which will be repaid as funds become available from surpluses in future years. With that investment included in the operating results, there was a $444,000 reduction of current fund surplus for the year.

The total return of the university's endowment was 16.9 percent for the year. The fund had a market value at June 30, 1995, of $142 million. The first half of calendar year 1995 was a positive period for the securities market and WPI's investment managers, overall, performed well in that market. This speaks well of the move over the last two years to engage a more broadly diversified portfolio and of the hiring of a distributed set of investment managers. WPI's return of 16.9 percent exceeds the average reported by the National Association of College and University Business Officers (NACUBO) of 15.5 percent for participating colleges and also exceeds the Actual Index established by WPI's Investment Committee by 0.3 percent.

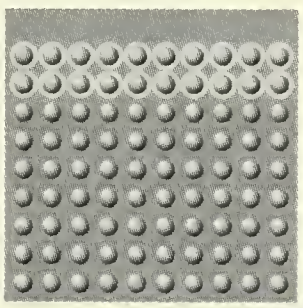
Sponsored research activity continued to grow. Even though the Center for High Performance Computing ceased as a department of WPI on Oct. 31, 1994, causing a reduction in total research expenditures of $1.4 million from the prior year, on-campus research actually increased by nearly $1 million during the year. Proposals submitted for the year exceeded the prior year by over 30 percent and awards received were nearly $1 million greater than the prior year.

Overall, at the end of FY 95, the total assets of the college increased by approximately $8 million to $234,328,993. Most of the increase can be attributed to two areas: growth in investments and construction in progress on the renovation of Higgins Laboratories.

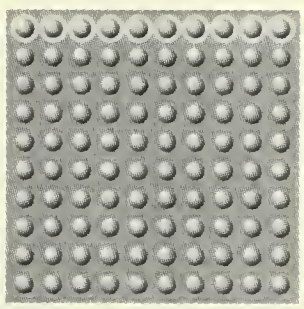
Revenues



Tuition, room and board, educational and other fees, **70%**

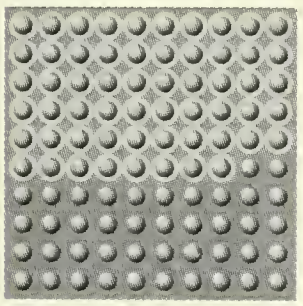


Endowment income, gifts and other internal revenue, **20%**

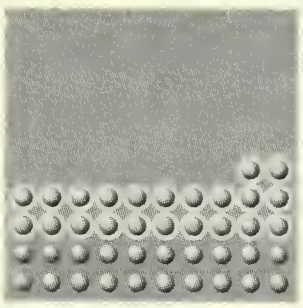


Other, **10%**

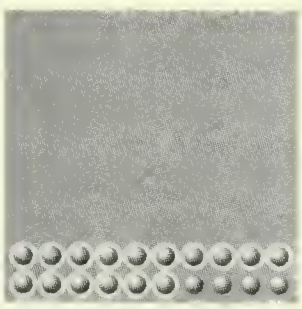
Expenditures



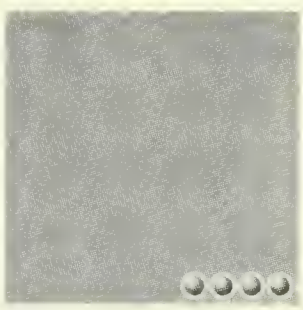
Direct expenses for educational and research operations, **58%**



Student aid, **22%**



Physical plant, computing and other administrative, **16%**



Other, **4%**

FINANCIAL HIGHLIGHTS

YEARS ENDED JUNE 30, 1995 AND 1994

1. General Operating Funds *(Thousands of Dollars)*	1995	1994	Percent Change
Tuition, fees and other educational revenues	$51,502	$48,837	+5.5%
Student financial aid	18,636	17,285	+7.8
Gifts, grants and bequests, as recognized	8,827	8,237	+7.2
Revenues from sponsored research programs	7,871	9,320	-15.5
Total staff benefit expenses, before allocation	7,276	7,198	+1.1

2. Endowment and Similar Funds *(Thousands of Dollars)*	1995	1994	Percent Change
Beginning market values	$127,600	$127,898	-0.2%
plus:			
Investment results			
Income (interest and dividends)	$4,743	$4,075	
Realized gains	1,274	1,855	
Change in unrealized gains	14,248	(2,907)	
Total investment results	$20,265	$3,023	+570.4
less:			
Used in support of college	(137)	(4,178)	+5.5
Transferred to restricted funds	(4,408)	(1,717)	-92.0
Net reinvested in endowment	(15,720)	(2,872)	
plus:			
Additions to endowments, mostly from gifts	9,087	2,574	+253.0
Ending Market Value	$152,407	$127,600	+19.4

Five-Year Summary of Total Return Data	'95	'94	'93	'92	'91
WPI Total Return	16.9%	4.0%	11.9%	12.4%	8.5%
WPI Policy Index	18.5	3.2	13.5	13.5	8.7
S&P 500	26.1	1.4	13.6	13.5	7.4
Shearson Lehman Int. Bond	10.4	-0.2	10.5	13.2	10.5
CPI Index	3.1	2.5	3.0	2.8	5.1

Copies of the complete audited financial reports for Worcester Polytechnic Institute for fiscal year 1995 can be obtained by writing to:

Office of Business Affairs
Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609-2280

EDITOR'S NOTE: *Every year at WPI is filled to overflowing with important events and accomplishments. It would be impossible to describe all of the noteworthy achievements of the 1994-95 academic year in the brief report that follows; instead, we've focused on a small number of stories that will give you a taste of the excitement of the busy year just past.*

Time Capsule:
A Look Back at 1994-95

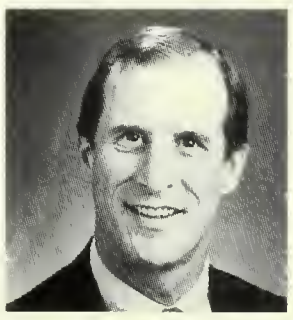
Like bookends, the departure of a president and the election of a new president marked the beginning and the end of the 1994-95 academic year at WPI. In late August 1994, Jon C. Strauss, the Institute's 13th president, announced that he would step down to become vice president and chief financial officer of the Howard Hughes Medical Institute.

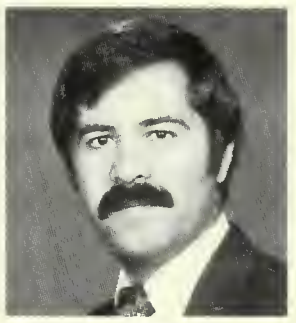
JONATHAN KANNAIR

The search for a new president began immediately. In November 1994, John Lott Brown '46, president emeritus of the University of South Florida and a trustee emeritus of WPI, was chosen to lead the Institute in the interim. The presidential search committee completed its work in the spring, bringing forward its choice for consideration by the Board of Trustees. At its annual meeting in May, the board unanimously elected Edward A. Parrish, dean of the College of Engineering and Centennial Professor of Electrical Engineering at Vanderbilt University, the 14th president of WPI. (For more on Edward Parrish and the interim presidency of John Lott Brown, see the Summer 1995 *WPI Journal;* for a look back at the presidency of Jon Strauss, see the Fall 1994 *Journal.*)

The election of a new president was just one of several changes in WPI's senior administration announced during the academic year. In April, Provost Diran Apelian announced that the positions of dean of undergraduate studies and dean of graduate studies and research would be combined to create a new position: associate provost for academic affairs. The move, Apelian said, was aimed at reducing costs, eliminating duplication of services and increasing efficiency. William W. Durgin, dean of graduate studies and research, was chosen to fill the new position on an interim basis.

Apelian also announced that at the end of the 1995-96 academic year he will step down to head the Center for Metal Processing (CMP) at WPI. Apelian, Howmet Professor of Mechanical Engineering, founded WPI's Aluminum Casting Research Laboratory and was instrumental in the creation of WPI labs engaged in research on powder metals and semisolid metal processing. The three labs now constitute CMP.





Top of page, President Edward Parrish (at podium) answers questions at a news conference announcing his appointment. Above, clockwise from top left, department heads Banks, Cheetham, Dittami, Keil and Hakim.

In June, President Brown announced that WPI's five vice presidential positions would be consolidated into four with the combination of the posts of vice president for administration and vice president for business affairs and treasurer. Stephen J. Hebert '66, formerly vice president for administration, was named to fill the new combined vice presidential post.

Several new academic department heads were appointed during 1994-95. Thomas H. Keil, a 28-year veteran of the WPI faculty, was named to head the Physics Department. Ronald D. Cheetham, who joined WPI in 1973, was named head of the Biology and Biotechnology Department. Hossein Hakim, who arrived at WPI in 1984, was named head of the newly constituted Interdisciplinary and Global Studies Division. And Col. Kenneth A. Stafford took over the Air Force/Aerospace Studies Department.

Two other new department heads began their terms at the beginning of 1995-96. They are James P. Dittami, at WPI since 1985, in Chemistry and Biochemistry, and McRae C. Banks II, formerly professor of management at Mississippi State University's College of Business and Industry, in Management. Chemistry and Biochemistry, previously Chemistry, was one of two departments to change its name last year. The Civil Engineering Department became the Department of Civil and Environmental Engineering.

Michael A. DiPierro '68, president of Baystone Corp., John C.S. Fray, program director, integrative animal biology, at the National Science Foundation, and Philip R. Morgan, president and CEO of Morgan Construction Co., joined the Board of Trustees in 1994-95. M Howard Jacobson,

senior advisor at Bankers Trust, concluded a highly successful term as board chairman in June 1995; John M. Nelson, chairman of Wyman-Gordon Co., was elected to succeed him.

The year just past also saw a number of important changes to WPI's physical plant. The renovation and expansion of Higgins Laboratories, the home of the Mechanical Engineering Department, was nearly complete by year's end. The $8.5 million project, begun in the spring of 1994, included the construction of a 17,000-square-foot addition on the west side of the building and the complete refurbishment and redesign of the interior of the existing structure. Among the new facilities created in Higgins is the Design Center, a suite of four labs and the Heald Discovery Classroom that will form the centerpiece of a new way of teaching engineering. A formal rededication ceremony will be held in the spring of 1996.

The Higgins Laboratories renovation was just one of the $13.5 million in construction projects in progress or in the planning stages during 1994-95. Under a $2.25 million energy conservation program, 10,000 light fixtures across campus were refitted with energy-saving ballasts and lamps and upgrades were made to motors, energy management and control systems, and water chillers. The work is expected to save WPI $200,000 annually in energy and maintenance costs. A $975,000 project completed in late summer 1994 extended the Institute's campus data and telephone network into every residence hall room.

Goddard Hall, the 30-year-old chemistry and chemical engineering building, benefited from a complete renovation of its ventilation system. The $720,000 project was designed to correct an extreme negative air pressure in the building and to reduce energy consumption. The reconstruction of Freeman Plaza, which stretches between Salisbury Laboratories, Gordon Library and Washburn Shops, was completed in the fall of 1994. The plaza was created in the 1970s with significant support from Howard G. Freeman '40 and his wife, Esther.

On tap for 1995-96 is the conversion of the portion of West Street that bisects the WPI campus into a pedestrian mall, a project expected to be undertaken in the spring of 1996. The Institute won the approval of the Worcester City Council in late summer 1995 to close the street, arguing that the move would increase safety and greatly enhance the quality of life at the Institute. The successful appeal, directed by Stephen Hebert and aided significantly by Trustees Chairman John Nelson, was the work of a host of faculty and staff members and students. Many other members of the WPI community, including a number of alumni, showed their support by signing petitions and attending the various city government meetings at which aspects of the closure were debated.

Several laboratories for research in biology and biotechnology will be renovated starting next year with a $1 million grant from the National Science Foundation. With the grant, which must be matched by gifts from alumni and friends of the Institute, WPI will modernize and upgrade labs for work in molecular genetics, invertebrate zoology and bioremediation, as well as several common research facilities, including a greenhouse and a microscope suite. A laboratory preparation area was renovated during the year with Institute funds. The project is set for completion in early 1997.

Plans for a campus center continued to advance during the year. The Campus Center Planning Committee, made up of members of the WPI community, fine-tuned the "program," or proposed contents, of the center and reported its choice for a site for the building to the Board of Trustees in February 1995. Based on its studies and input from the community, the committee recommended that the center be located in Alumni Gymnasium and that an addition be built behind Alumni Gym to house the recreational facilities displaced by the construction.

PHOTOS BY NEIL NORUM

Though it did not change in any significant way during the year, Stratton Hall garnered a great deal of attention from the WPI community in December 1994 when it turned 100. The building, now home to the Mathematical Sciences Department, the Office of Human Resources and several Plant Services operations, was WPI's first mechanical engineering building. Built with funds from the commonwealth of Massachusetts, the structure is named for Charles G. Stratton, Class of 1875, a WPI trustee and president of the Alumni Association.

Also noting their centennials in 1994-95 were Alden Research Laboratory and the WPI-RPI football rivalry. ARL, a world-famous facility for hydraulics research and development, was founded in Holden, Mass., by George I. Alden, WPI's first professor of mechanical engineering. It was reorganized as a private corporation in 1986.

In addition to the WPI/RPI football anniversary, the year's other top sports story

was the establishment of the women's varsity soccer team last spring; women's soccer had been a club sport since 1986.

As construction workers labored to restore the Institute's buildings, a host of individuals were endeavoring to spruce up and renew the work of education that goes on within those structures. The Chemical, Civil and Environmental, and Mechanical Engineering departments completed reviews of their curricula during the year, while Biology and Biotechnology, Chemistry and Biochemistry, Mathematical Sciences, and Mechanical Engineering implemented innovative new approaches to laboratory instruction. The Computer Science Department, one of the first such departments in the nation to receive accreditation by the Computer Science Accreditation Board, won reaccreditation in 1994-95.

Now and Then. Opposite page, from top, highlights from 1995: an artist's rendering of the new West Street pedestrian plaza; the new addition to Higgins Labs; President Parrish greeting members of the new women's varsity soccer team. This page, from top, 100-year anniversaries from 1895: the WPI football team that first faced RPI; Alden Research Lab (circa 1920); Stratton Hall just after it was dedicated.

After a three-day conference on campus in June 1994 aimed at finding ways to improve the first-year experience for WPI students, a number of faculty and staff members and students worked during the year to develop new initiatives that increase comprehension and retention of fundamental concepts by better linking first-year math and science courses, and to integrate the new student orientation with programs that help students develop academic and study skills. A conference in February 1995, attended by 60 members of the WPI community, continued work toward a comprehensive pluralism program.

An important aspect of WPI's commitment to a pluralism program is the recruitment and retention of underrepresented students of color. Through the efforts of the Office of Minority Student Affairs (MSA), WPI's entering population of underrepresented students grew from 16 in 1991 to 35 in the fall of 1995, an increase of 102 percent. Retention rates have improved to 75 percent, greater than the national average for underrepresented students enrolled in engineering majors.

As a result of this success, WPI's Excellence in Mathematics, Science and Engineering Program (EMSEP) in October 1995 was named one of nine outstanding institutional academic advising programs by the National Academic Advisors at the group's annual conference in Nashville. The following month, the GE Fund awarded MSA a $104,000 grant to enhance EMSEP support services by developing academic excellence workshops and supplemental instruction programs in historically difficult courses. The Mathematical Sciences and Physics departments will work with MSA in launching the new initiative over the next two academic years.

In April 1995, Bernard H. Brown, vice president for student affairs, endorsed a proposal to establish a standing committee on the status of women at WPI. The proposal was developed by a study group appointed by President Strauss in the summer of 1994 to review the status of advocacy for women at WPI and to compare WPI's services and programs for women with those offered by peer institutions.

The Davis Educational Foundation provided WPI with a third year of funding for an innovative program designed to improve the quality of undergraduate education at the Institute, and also increase faculty productivity. The first two years of the program produced measurable changes in the way many freshmen and sophomores learn, how they feel about the process of learning, how courses are taught, and how faculty members use their in- and out-of-class time.

The Fred Harris Daniels Foundation awarded WPI $25,000, the nucleus of a fund that will help the Institute enhance its writing and foreign language programs. The grant will fund the creation in Salisbury Laboratories of a multipurpose computer lab where students will work alone or in small groups on homework assignments and independent projects, and a networked classroom, where faculty members will supervise group writing projects or group communication via computer.

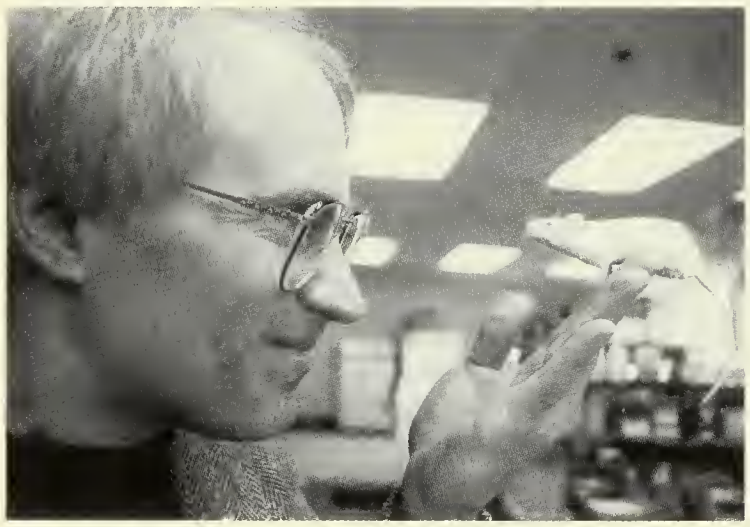
Also in 1994-95, the faculty approved the creation of new interface disciplines—educational programs in emerging technologies and other technology based initiatives that lie at the boundaries of WPI's existing academic programs. The concept of the interface discipline was outlined in 1992 by the Blue Ribbon Task Force, which suggested that such programs can build on WPI's strengths and appeal to students who might not otherwise consider enrolling at a technological university. The list of interface disciplines now includes Entrepreneurship, Environmental Policy and Development, International Studies, the Pre-Health and Pre-Law programs, Technical, Scientific and Professional Communications, Theatre and Theatre Technology, and Industrial Engineering.

The faculty also approved two new options within the undergraduate program: the concentration and the minor. The concentration formally recognizes focused and coordinated work within a major or within an area of study closely related to a major. Examples include mechanical engineering with a concentration in biomedical engineering and electrical engineering with a concentration in computer engineering. A minor requires a minimum amount of thematically related activities, including courses and projects, outside the bounds of a student's major. A portion of the work must constitute a "capstone" that marks the completion of the minor. To date, the faculty has approved minor programs in computer science, economics, international studies, law and technology, and management.

In the fall of 1994, WPI formally opened the Technical Education Center in Westborough, Mass. Under the direction of the Office of Continuing Professional Education, the center's mission is to offer certificate programs and seminars that meet the

continuing education needs of technical and managerial professionals. The center's first offering, four eight-week day classes and three 26-week part-time classes in UNIX Systems/C Programming, was a tremendous success. The Continuing Education Office also delivered 89 public seminars in project management, quality improvement and management development and 70 in-house corporate training programs (double the number presented in 1993-94) during the academic year.

Also in the fall, the Washington, D.C., Project Center, the Institute's first residential off-campus center for academic project work, celebrated its 20th anniversary. A number of the students who've completed projects at the center gathered with other members of the WPI community to observe the anniversary at a reception in Washington. The Washington Project Center was the launching pad for WPI's Global Perspective Program, which now operates project centers and programs and exchange programs in more than 18 nations on five continents.



PHOTOS BY NEIL NORUM

Many members of the WPI faculty and staff garnered awards and honors during the year. Here are a few highlights:

- Lance E. Schachterle, assistant provost for special programs and professor of English, won the 1995 Sterling P. Olmstead Award from the American Society for Engineering Education. The award honors innovative contributions to the liberal arts within engineering education. Dean of Undergraduate Studies Emeritus William R. Grogan won the Olmstead Award in 1988.
- Samuel Rankin announced his decision to step down as head of the Mathematical Sciences Department to join the American Mathematical Society full time. Rankin has been on partial leave at AMS since 1991, where he has worked on Sloan Foundation-sponsored projects on nonacademic employment for mathematical scientists and increasing the participation of minorities in the study of math. In the fall of 1995, Rankin was named associate executive director of AMS.
- In February 1995, David Adams, associate professor of biology and biotechnology, was second author on an important paper in *Nature*, the weekly international journal of science. The paper announced a breakthrough in research on Alzheimer's disease—the development of a strain of mice that mimics brain damage from the disorder.
- Chrysanthe D. Terwilliger '88, assistant professor of mechanical engineering, and Barbara E. Wyslouzil, assistant professor of chemical engineering, received major monetary awards from the National Science Foundation's Faculty Early Career Development Program. The program is designed to encourage the early development of academic faculty members as educators and researchers.
- Grover A. Swartzlander Jr., assistant professor of physics, became the fourth WPI professor to be named an NSF Young Investigator (formerly Presidential Young Investigator). Previous winners are James E. Rollings, associate professor of chemical engineering, Tahar El-Korchi, associate professor of civil and environmental engineering, and Peter L. Levin, associate professor of electrical and computer engineering. In the fall of 1995, Levin received another major honor when he was named a White House Fellow; he is on leave in 1995-96 serving as a special assistant to the chairman of the Federal Communications Commission.
- Albert Sacco Jr. spent the 1994-95 academic year training for his role as payload specialist on the flight of the second United States Microgravity Laboratory (USML-2). Sacco was chosen in June 1994 as one of two payload specialists for the mission, which flew aboard the NASA space shuttle *Columbia* in October 1995. Among the many experiments on the mission was the Zeolite Crystal Growth Experiment. Sacco, as principal investigator, headed a team of WPI faculty members and students that readied this experiment for its third flight on a space shuttle mission.

PHOTO BY GIACOMO FERRARO JR

Top, Adams with mouse that may help fight Alzheimer's disease. Bottom, NSF Early Career Development Grant winners Terwilliger, left, and Wyslouzil. Right, Sacco and the crew of USML-2 prepare to board *Columbia* on launch day.

NASA Astronaut Kathryn Thornton, payload specialist for the USML-2 mission, was the speaker at WPI's 127th Commencement in May 1995. Thornton received an honorary doctorate, along with Robert Daniell, chairman of United Technologies Corp., Milton Garland '20, senior consultant for technical services at Frick Co. (and, just shy of his 100th birthday, WPI's oldest honorary degree recipient), and Paul S. Morgan, chairman of Morgan Construction Co. and the fourth generation of his family to serve on the WPI Board of Trustees (he served from 1966 to 1991 and was chairman from 1978 to 1983). Some 833 students received degrees. The ceremony, held on the Quadrangle, marked the formal conclusion of one of the Institute's most productive and eventful years.

—Michael Dorsey

Institutional Advancement: Building for the 21st Century

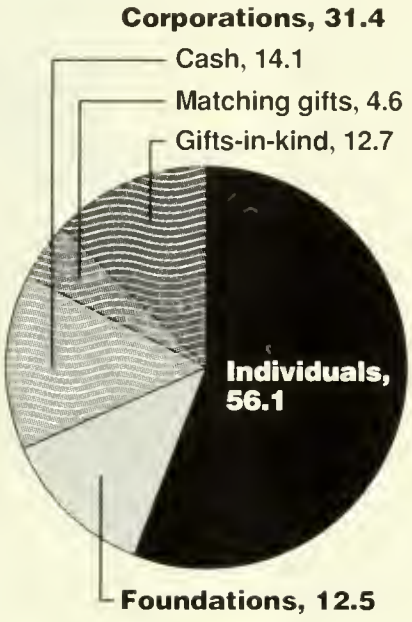
By Ronald C. Baird
Interim Vice President for University Relations

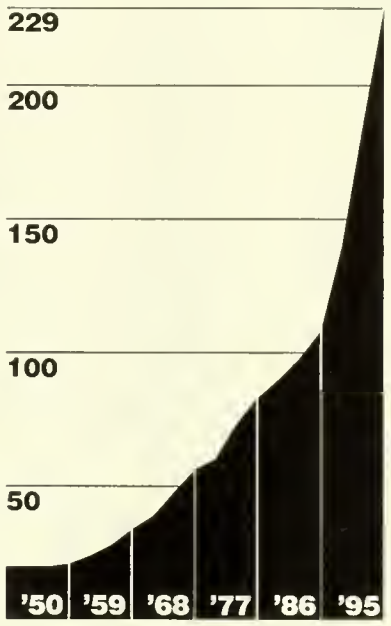
A reporter once asked hockey great Wayne Gretsky how it was that a player of his modest physical abilities became the game's all-time leading scorer. After a moment's reflection, the "great one" answered simply that he always attempted to move to where he thought the puck would be, while other players seemed to move to where the puck was at that moment. On such simple premises are built the foundations of great accomplishment.

An institution, no less than an athlete, must focus on the future if it is to attain new levels of excellence. As WPI sets its sights on the 21st century under new leadership, it must continually focus on those things that have enabled it to achieve distinction. Among the most important is its fund-raising infrastructure: generous donors, conscientious trustees, enthusiastic volunteers, hard-working staff—in short, the essential human resources who contribute to the business of raising the financial support so necessary to the sustained excellence of this distinguished technological university.

It has been my distinct pleasure and privilege to have served the Institute as vice president for university relations and to have helped build a foundation in institutional advancement that will carry WPI well into the next century. That building process forms the background to what has been another excellent year in development. To begin with, WPI received $9.5 million in gift revenue and nearly $2 million in pledges during 1994-95. While those totals are somewhat lower than those of the record years 1992-93 and 1993-94, the year just past was, nonetheless, among the top five in WPI history.

Planned giving, at over $2.8 million for the year, is a rapidly growing vehicle for philanthropic donations; WPI has a portfolio of over $19 million in deferred gifts (unitrusts, bequests, life insurance and so on). Corporations and foundations continue to be major sources of gift revenue for the school, accounting for 31.4 percent and 12.5 percent, respectively, of total dollars received in 1994-95. Indeed, the $1.7 million in cash gifts received from corporations last year was an Institute record.





Left, the sources of the $9.5 million in gift revenue WPI received during the 1994-95 fiscal year. Corporate giving is further broken down into its three components. Right, the exponential growth in Presidential Founder membership over the past half century. Formally established in 1986, the group recognizes individuals and family foundations whose cumulative gifts to WPI have equaled or exceeded John Boynton's founding gift of $100,000.

Our cadre of major donors continues to grow. The Presidential Founders, the George I. Alden Society and the President's Advisory Council all recorded healthy increases during the year. It's hard to believe that just 10 years ago WPI could point to only 105 individuals or family foundations whose lifetime giving to WPI totaled at least $100,000. That figure now stands at 229, with 11 new Presidential Founders having joined the ranks in 1994-95. The Alden Society, which honors those who have included WPI in their wills or estate plans for at least $25,000, has grown from 154 members in 1992 to 182 today. That is a tribute to the many alumni and friends whose generosity has helped establish new standards for giving at WPI.

Among the year's other development highlights was the "minicampaign" for Higgins Laboratories. The renovation and expansion of this home for mechanical engineering at WPI is virtually complete, with $9.5 million in cash and equipment donations now in hand (well in excess of our $8.4 million goal). Almost two-thirds of the cash total came from local and national foundations. That is a testament to the innovative planning and foresight represented by this project, which is a cornerstone of WPI's vision for the 21st century.

A new minicampaign, announced this year, will support WPI's research and educational programs in biology and biotechnology. The Institute has received about $1 million from the National Science Foundation to help create new biology research laboratories in Salisbury Laboratories. An additional $1 million will be needed to complete the work, and the university is committed to matching the NSF grant over the next two years with gifts from a wide range of supporters. Over the last five years Biology and Biotechnology has experienced the largest increases in undergraduate enrollment of any department at WPI.

The Council for the Advancement and Support of Education (CASE) acknowledged WPI's success in fund raising by selecting

The bottom line is that our fund-raising infrastructure of loyal, generous donors continues to make possible the advancement of WPI in so many critical areas and programs.

Ronald Baird accepts the CASE Circle of Excellence Award from Susan Kubik, chair of the board of CASE.

the Institute to receive one of its 1995 Circle of Excellence in Educational Fund Raising Awards. This prestigious award, which recognizes excellence in fund raising over the previous three-year period, places WPI in some very select company, indeed. The other winners in our category (private research/doctoral institutions) were Brown, Columbia, Duke, Harvard, Stanford, Notre Dame and the University of Chicago.

In other developments, the Polaroid Foundation established a challenge grant for equipping a new image processing laboratory in Atwater Kent Laboratories for the Electrical and Computer Engineering Department. The challenge will call on our many alumni at Polaroid to give to WPI through the foundation's matching gift program. The gifts and matching gifts will be applied to help meet the challenge. Corporate matching gift programs are an important source of unrestricted funds for WPI. Each year they make possible strategic investments in critical programs.

A grant from the Sloan Foundation for a study of fragmented industries and a third year of funding from the Davis Educational Foundation for a program aimed at enhancing teaching productivity at WPI are exciting, far-reaching initiatives with national implications. The bottom line is that our fund-raising infrastructure of loyal, generous donors continues to make possible the advancement of WPI in so many critical areas and programs.

The real story in institutional advancement in 1995 was the implementation of a long-range plan to build a permanent fund-raising infrastructure of sufficient dimension and sophistication to ensure an increasing flow of private support to WPI indefinitely. The plan stems from the recognition that our donor base continues to expand and philanthropy is becoming increasingly complex and information-intensive.

Five major steps in that long-range plan were implemented in 1994-95. They were

- an internal reorganization of the University Relations Office. As a product of that reorganization, the Alumni Office and the Alumni Fund now report to the vice president for university relations.
- the development by the WPI Alumni Association of a five-year strategic plan for the Alumni Fund. The plan outlines a program for substantially increasing both the number of donors and the number of dollars received by the fund annually. It calls for additional investments in human resources to enable WPI to expand its alumni programs.
- a quarter-million-dollar investment in computer software and hardware that will enable the University Relations Office to employ the latest in information technology well into the next century.
- a long-range plan for financing the expansion of our fund-raising infrastructure, which was approved by the Board of Trustees in September 1995. As a result, three new positions were created in University Relations and several functional areas were reorganized. The new positions will be filled during 1995-96.

These steps will put in place a highly professional fund-raising infrastructure that will enable WPI to compete for private sector financial support and increase alumni participation. They will also form the core organization with which WPI will conduct its next capital campaign.

The successful implementation of the new long-range plan for fund-raising will depend, above all, on support from WPI's many alumni and friends, who understand the role of development in positioning this distinguished university for greatness in the coming century. The commitment and willingness of these supporters to invest in the future is what separates the great institutions from the good. To you, once again, our sincere thanks.

John Heyl Takes Over the Reins

As 1994-95 came to an end, WPI began a search for a new vice president for university relations. That search ended successfully with the recent appointment of John L. Heyl, a 25-year veteran in development and institutional advancement.

Heyl earned his bachelor's degree at Trinity College in Hartford, Conn., and taught at Brown University and Hyde School in Bath, Maine, before returning to Trinity in 1970 as director of alumni relations. From 1974 to 1976 he was the director of the Harvard Business School Fund. He then became development director at Woods Hole Oceanographic Institution.

In 1981 he was named vice president for development at Bowdoin College, where he also oversaw public relations, publications and alumni relations. While at Bowdoin, he directed a $56 million capital campaign.

From 1987 to 1991 he was vice president for resources development at the National Trust for Historic Preservation. He then served as vice president for development, membership and marketing at Conservation International in Washington, D.C. In 1993 he became a principal in Alumni Hotels Inc., a membership benefit program for university alumni associations with more than a million alumni participants and a worldwide network of hotels.

"We're extremely pleased to have John join our community," WPI President Edward Parrish said. "His considerable experience will play a critical role in the advancement of this institution as it approaches the next century."

1994-95 WPI HONOR ROLL OF DONORS

WPI gratefully acknowledges the support of the thousands of individuals, foundations and corporations whose contributions of $9,427,371 in cash and gifts-in-kind through the Alumni Fund, the Parents Fund, minicampaigns and general development efforts during the 1994-95 fiscal year (July 1, 1994, to June 30, 1995) are already at work making WPI a stronger and more outstanding institution. Space does not permit the listing of all their names. An additional $1,958,153 was pledged during the fiscal year. These commitments will be listed in future reports as they are received as cash or gifts-in-kind.

$100,000 and above

George I. Alden Trust
John Lott Brown '46
China Technical Consultants Inc.
William J. Coffey/Walter L. Goodwin*
Commonwealth of Massachusetts
Davis Educational Foundation
John F. Devaney '31
Digital Equipment Corp.
Robert D. Fellman
Robert A. Foisie '56
Mrs. Richard A. Heald '20
Hewlett Packard Company
Howmet Turbine Components Corp.
Mrs. Alba Y. Kalenian '33
Raymond J. Perreault '38
Carl E. Rylander '31
Alfred P. Sloan Foundation
Dr. Stedman W. Smith '36
United Technologies Corp.
Leonard A. ('37) and Joy P. Young Trust

$25,000 to $99,999

Estate of Milton H. Aldrich '28
Mrs. Edward K. Allen '33
AT&T
Bailey Control Company
Robert H. Beckett '57
Ruth H. and Warren A. Ellsworth Foundation
Exxon Education Foundation
Henry J. Ezen '49
Martin R. Flink Jr. '45
Ford Motor Company Fund
Raymond J. Forkey '40
General Electric Foundation
General Motors Corp.
The Gillette Company
GTE Corporation
Hoche-Scofield Foundation
Hughes Aircraft Company
August C. Kellermann '46
The Macamor Foundation
Thomas M. McCaw '46
Mildred H. McEvoy Foundation
Metal Powder Industry
John C. Metzger Jr. '46
Motorola Inc.
Norton Company
Roger N. Perry Jr. '45
Procter & Gamble Company
Richard Prouty
Raytheon Company
Tarek M.A. Shawaf '55
The Starr Foundation
Robert C. Stempel '55
Texaco Inc.
WPI Alumni Association

$10,000 to $24,999

Estate of Phyllis E. Aldrin
Aluminum Pechiney
Amoco Corporation
Bio-Imaging Technologies Inc.
Martin G. Bromberg '51
Mrs. Arthur H. Burr '29
Cabletron Systems Inc.
CMI International
Edward S. Coe Jr. '31
Coleman Foundation Inc.
Consolidated Metco
Donald G. Craig '57
Paul M. Craig Jr. '45
Paul C. Disario Jr. '42
Doehler-Jarvis
Gerald F. Dyer '56
Environmental Soil Management Inc.
Mrs. Frank H. French '29
George F. and Sybil H. Fuller Foundation
William R. Grogan '46
John P. Harding Jr. '47
Hoeganaes Corp.
Peter H. Horstmann '55
Estate of Mary Howard '14
IBM Corporation
ICM/Krebsoge
Ingersoll-Rand Company
Rolf Jensen & Associates
Keystone Carbon Company
C. Stanley Knight '32
Paul N. Kokulis '45
Gordon B. Lankton
Liberty Mutual Insurance Co.
C. John Lindegren Jr. '39
Mobil Foundation Inc.
Monsanto Fund
Northeast Utilities Service Co
Polaroid Corporation
Presmet Corp.
Quebec Metal Powders Limited
Reynolds Metals Company
Schlumberger-Doll Research
SCM Metal Products
John J. Shields '69
Raymond B. Shlora '40
Henry M. Strage '54
John G. Underhill '44
Windfall Products Inc.
Xerox Corporation

$5,000 to $9,999

Andersen Consulting
Richard H. Anschutz '46
Milton D. Bartlett '45*
BASF Corporation
Anna Harrington Boardman*
Robert M. Buck '45
Murray A. Cappers Jr. '57
Raymond K. Chafin '46
Leon Chahinian '56
CIGNA Corporation
Stanley C. Clevenger '55
Mrs. B. Austin Coates Jr. '35
Dr. and Mrs. Noel L. Cohen *p*
Daniel I. Coifman '67
Comalco Aluminum Ltd.
F. H. Daniels Foundation Inc.
Design News
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Mrs. Dwight Dwinell '34
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Neil A. Fitzgerald '38
Dale G. Freygang '74
A.J. Gifford Charitable Trust
Alfred E. Green '45
Arnold M. Hall '56
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